POWER

Vol. 38 NEW YORK, SEPTEMBER 9, 1913 No. 11

"Engineer" or "Greaser"?

When an engineer is alluded to as a "greaser" we may rightly assume that the humorist is the bigger and stronger man. It requires might, brawn and muscle to be ingenuously truthful even after one thousand nine hundred and twelve years of Christian influence, for truth is often harsh and uncompromising.

"A greaser is a man that greases or oils machinery," says my dictionary. "An engineer is one that cares for, repairs or erects engines and their auxiliaries." Had the dictionary writer compiled his vocabulary for the sole use of engineers he would have an (a) and a (b) meaning to the word "greaser," or he might have left the word out altogether for no one in the trade would have to turn to it to understand both interpretations.

"Greaser or engineer! To which class do I belong?" is the natural query. "Have I the qualifications to be classed as an engineer under the Websterian definition? Should I froth at the mouth and grip tighter my wrench when the derogative name 'greaser' is applied to me? Were a duck to waddle into the engine room and squawk, 'Quack!' under my nose, would I be justified in masticating goose bones at my next day's lunch?"

Let—me—see.

If the eccentric of my engine slipped, can I intelligently reset it? If I cannot, I am a "greaser." If the load is suddenly thrown off or the governor belt breaks, will the engine run away? If it will, "greaser" and not "engineer" properly applies to me.

Do I know the steam consumption of my engine, and how favorably (or otherwise) it compares with the known economy of others? If I do not, I am not an engineer. Does my engine thump and pound, and my valve-gear rattle? If they do, I am the opposite of an "expert"—a quack. Many more—very many more—are the questions which I, and you, could ask, and on candid answers will depend our claim to that which the uninitiated public terms us, "engineers."

I was lost in this self-examining mood when a visitor entered the engine room and asked: "Are you the engineer?" I suppose he wondered why I flushed, hesitated and faintly stammered "Yes." Thereupon he asked me to show him around the plant. When this was done, no doubt he was able to judge for himself, whether or not I was an "engineer."

Apropos of this, here is a little poem by Herbert Kaufman that is worth reading:

SHOW US

You say that you *deserve* success;
Pitch in, and start to *show* us.
We think that you deserve *far less*,
And *ought* to be *below* us.
It's up to *you* and what you *do*,
Mere empty *words* won't *change* our view.
Come, prove our viewpoint isn't *true*!
Results are all that we will *count*;
If you can *climb*, begin and *mount*;
Present your case—we're on the jury;
But *all* of us are from *Missouri*.

Will your plant stand the test of "Show us"? Will its condition indicate that "greaser" is the right term to apply to *you*?

[*Written by R. O. Richards, Framingham, Mass.*]

Operating Boilers under Difficulties

By F. J. Ravlin

SYNOPSIS—Difficulties encountered in operating a steam plant in the winter while installing four additional boilers. Steam gages and water columns froze and frozen fuel was used while installing a conveying system.

The boiler plant of a large railroad shop, consisting of eight 250-hp. water-tube boilers, was too small to carry the heating and power load, and four more boilers were added. An extension on the north end of the boiler room to accommodate them and leave space for a future addition of four more was built.

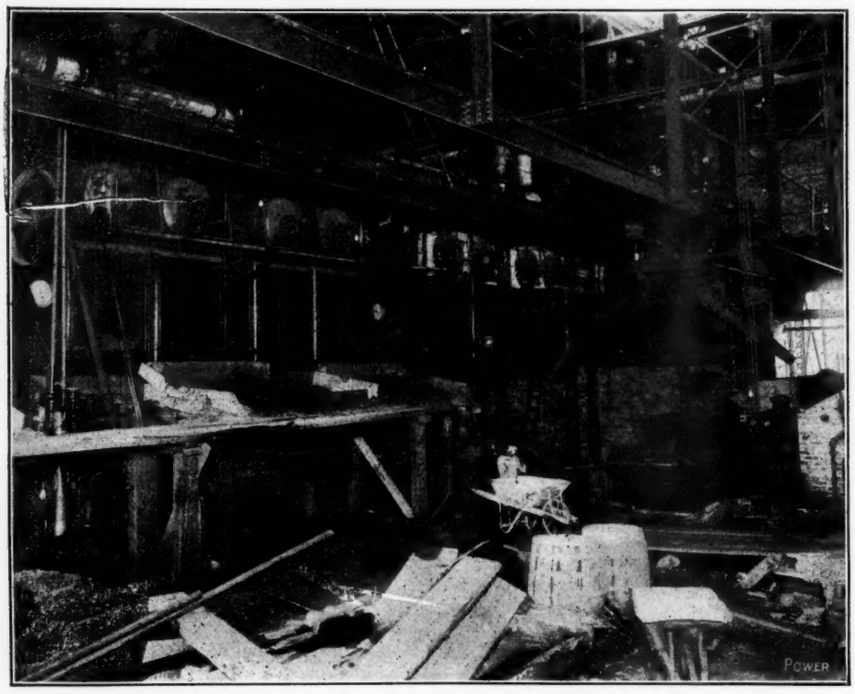


Fig. 1. Boiler Room from East End

On account of various delays the work was not well under way until cold weather, at which time the boiler-room roof was off and the entire west end of the boiler plant was exposed to the elements. A rough shed was built over the west and north ends of the plant, but in severe weather the temperature frequently went down to 15 deg. below zero and the gages and water columns were frozen while in operation.

The coal elevator had been removed and all the coal was brought in by wheelbarrows from the west end of the building on a platform and dumped into the top of the chain-grate hoppers, Fig. 1. It required 25 laborers, day and night, to dig the frozen coal (screenings) from the cars, load it into wheelbarrows, dump it into the hoppers and remove the ashes from the pit into wheelbarrows and wheel them out into the cars on the west side of the station. Eight boilers were in operation from Nov. 1 to June 1, without interfering with the shop service.

After the building was completed and the four new boilers were in operation, four of the old settings were torn down and the floor excavated between the old and new batteries. The old boilers were thoroughly cleaned and inspected and horizontal baffles substituted for the vertical baffles.

The view of the west side of the power station, Fig. 2, shows the new coal elevator and storage bin of 700-ton capacity. A pneumatic ash conveyor takes care of the four new boilers on the north side of the boiler room and will eventually serve the eight old boilers on the south side of the room. A 50-ton ash tank on the west side of the coal bunker discharges the ashes into a car on the coal track.

The resetting of the old boilers was accomplished by placing two 20-in. steel I-beams over each end of the drums and bolting the old framework through these I-beams so that the boiler was supported, allowing the excavating to be done under the entire battery at one time. The

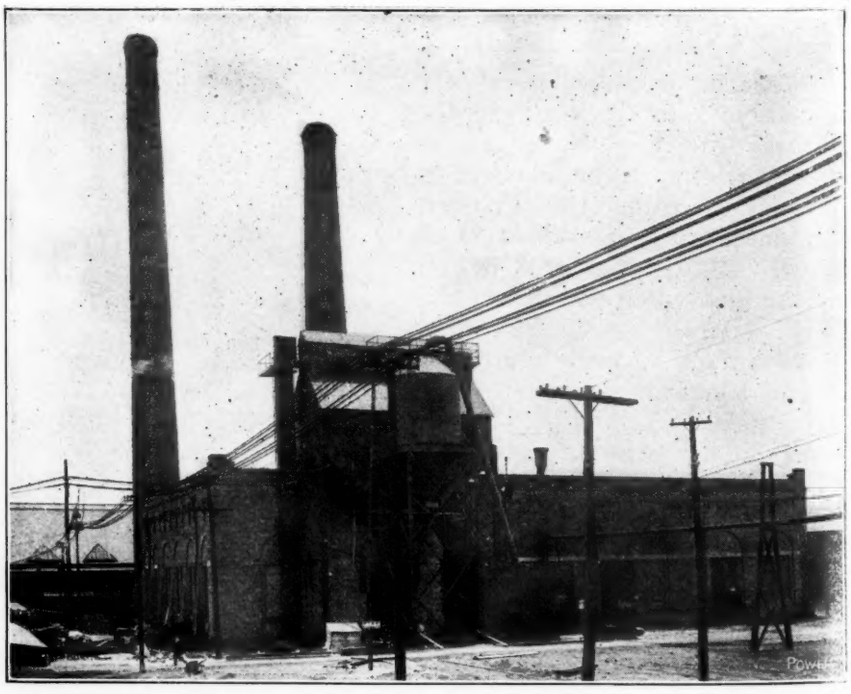


Fig. 2. West Side of Power Station

beams could be slid from one boiler to another. The scheme materially expedited the work and danger of accident from the excavating was minimized.

The horizontal baffles have entirely eliminated the smoke from the reset boilers. Analysis of the ash from these two settings showed 24% combustible from the old style and 10% in the ash from the new-style setting.

Fig. 2 shows the two stacks in operation with four boilers on the old and four boilers on the new one. Coal is received in drop-bottom cars and is unloaded into a hopper under the track at the west end of the station. Thence it goes through a coal crusher and is elevated to the storage bin. Drawn from the bottom of this bin into a 7-ton trolley car, it is distributed to each individual furnace, the hopper of which holds approximately 1½ tons. This plant consumes on the average 200 tons of washed screenings per day during severe winter weather and 125 tons during the summer.

❋ ❋

Factors of Safety and Insurance*

SYNOPSIS—An appeal for higher and more uniform rates for boiler and flywheel insurance and casualty lines in general.

❋

Factor of safety in engineering is the ratio of breaking strength to safe load. Correspondingly, factor of safety in insurance is the ratio of underwriting profit to premium income. A successful engineering structure must have a fair factor of safety, and likewise a successful line of insurance must produce a fair underwriting profit.

In engineering a hazardous structure demands a high factor of safety, and likewise in insurance a hazardous line demands a high margin of profit. The underlying reason is the same in both instances. In engineering the factor of safety takes care of variations in the supposed strength of the material, variations in workmanship, and conditions unforeseen at the time the structure was designed. In insurance the margin of profit takes care of variations from the general average for that particular hazard, incomplete or misleading information given to the underwriter, and conditions unforeseen at the time of rating the risk.

An assumed factor of safety in engineering is composed of two parts, a real factor of safety, and a pure factor of ignorance. An assumed factor of safety in insurance is likewise composed of these two parts.

Engineering Factors of Safety

These remarks may be exemplified as follows: For a steel roof truss a factor of safety of three is sufficient, because the maximum loading expected to be imposed upon it in service can be estimated beforehand, and because the strength of structural steel is uniform and dependable.

For a steam boiler a factor of safety of five should be employed, because the strength of boiler steel is not uniform, even in different parts of the same plate, because the strength is affected by the heat of the furnace, because the workmanship on the boiler cannot be depended upon, and because the safest of boilers is a dangerous menace to life and property.

For flywheels a factor of safety of ten on strength should be employed because they are made of cast iron, a material of such uncertain strength and low ductility that it may easily be fractured, because dangerous shrinkage strains are set up when the wheel is cast, because a factor of safety on strength of ten is equivalent to a margin of safety on speed of but little more than three, because the safety of the wheel is dependent upon governing mechanism which may get out of order and allow the wheel to race, and because a rotating flywheel is a dangerous menace to life and property.

Insurance Factors of Safety

The insurance factors of safety in liability risks, in workmen's compensation risks, in steam-boiler risks, and in flywheel risks are largely dependent upon the engineering factors of safety. For example, if a roof falls, a boiler explodes, or a flywheel disrupts, the engineering factor of safety is wiped out and likewise the resultant property loss and personal injury damages may be sufficient to wipe out the insurance factor of safety. The insurance factor of safety is also largely dependent upon the number of risks in force, because the premium income from a small number of risks might not contribute enough in the lifetime of a company to pay for a single disastrous loss. The factor of safety in insurance also depends upon many other things, most important of which is a well devised system of accident prevention, and not the least important of which is efficiency of management.

Boiler- and Flywheel-Insurance Factors of Safety

Compared with other lines the volume of boiler insurance written is small, the annual income of all companies combined being only $2,568,000—and the engineering factor of safety is high. Correspondingly, then, the insurance factor of safety should be high. It is, however, now so low that it is exceedingly difficult for even the larger-volume companies to show an underwriting profit. That smallness of volume seriously affects its factor of safety is shown by the interesting experience of a company that has a volume of boiler insurance approximating only $20,000 annually. During one year it had a loss ratio of only 1 per cent., and during another year it had a loss ratio of nearly 140 per cent. That is to say it paid out for losses alone 40 per cent. more than it received in premiums.

The total volume of flywheel insurance written annually is even less than the total volume of boiler insurance; and the engineering factor of safety for flywheels is greater than the engineering factor of safety for boilers. Correspondingly, then, the factor of safety for flywheel insurance should be higher. This is confirmed by the fact that the combined loss ratio of all companies on flywheel insurance is higher than their combined loss ratio on boiler insurance. That smallness of volume seriously affects its factor of safety is shown by the experience of a company that has a volume of flywheel in-

*Abstract of a paper read by W. H. Boehm before the International Association of Casualty and Surety Underwriters.

surance approximating only $4000 annually. During one year it had a loss ratio of nothing, while during another year it had a loss ratio of over 300 per cent. That is to say it paid out for losses alone three times as much as it received in premiums.

Another company having an annual income of only $1000 from flywheel insurance, during one year had a loss ratio of nothing, and during another year had a loss ratio of nearly 1000 per cent. That is to say, it paid out for losses alone nearly ten times as much as it received in premiums. It is interesting to note in passing that even the larger-volume companies are sometimes hard hit. For, during the first three weeks of this year, a company that writes a large volume of boiler insurance sustained losses from three boiler explosions that aggregated nearly $200,000. It is readily seen from this how easy it would be for a single disastrous explosion to more than wipe out for a number of years an estimated underwriting profit of 5 to 10 per cent.

Factors of Safety for Casualty Lines in General

Extracts from the financial statements for 1912 of companies transacting various casualty and liability lines indicate that of the 69 companies transacting these lines, 36 sustained an underwriting loss; and the combined results of the entire 69 companies showed a net underwriting loss of 0.6 per cent. Great variations are observed in the percentages of underwriting profits and losses, ranging from a profit of 41.8 per cent. to a loss of 158.4 per cent. of the premium income. Grouped under the head of each line written, casualty companies show an underwriting loss of 1.5 per cent., surety companies a profit of 1.8 per cent., plate-glass companies a profit of 6.9 per cent., and remaining companies a loss of 0.5 per cent.

During the past ten years the combined underwriting profits of these 69 companies steadily decreased. The vanishing point was reached in 1911, when there was a substantial underwriting loss. The loss in 1912 was even greater than in 1911, from which it is apparent that something must be accomplished to better the factor of safety, if stockholders are to receive a fair dividend on their investment and policyholders are to have proper guarantees for the payment of future losses.

Steam-Boiler and Flywheel Insurance

The steam-boiler and flywheel business has been in more or less of a demoralized state ever since the competitive writing of these lines began. There has been no coöperation as to insurance requirements for the proper construction and safe operation of boilers and flywheels; and there has been no interchange of experience or statistics, or opinions as to the rates for which steam-boiler and flywheel insurance could be written with safety. Company after company has entered the field, depressed rates, demoralized the business generally, and then retired. The cost of boiler and flywheel inspection has steadily increased on account of the increase in the hotel and traveling expenses of inspectors, and the increasing mass of data required to be placed on file by state authorities. The loss ratio has increased on account of the greater amounts that must now be paid for personal injury losses under the new liability and workmen's compensation laws, and for other reasons. Rates have steadily decreased until they are now too near the danger line.

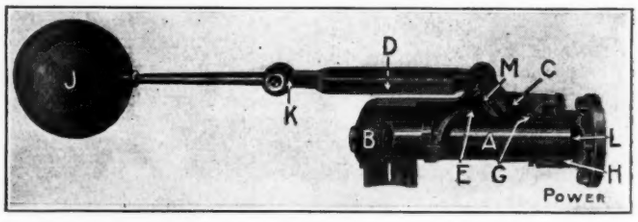
Bettering the Factor of Safety

The remedy for this condition, not only as respects steam-boiler and flywheel insurance but as respects other lines of the casualty and surety business, lies in coöperation. It is essential for the mutual interests of all the the companies may be compiled, and equitable rates based and that a bureau be maintained for each line of insurance transacted, in order that the combined experience of all the companies be compiled, and equitable rates based upon this combined experience be formulated, and strictly adhered to. Printed manuals containing such rates may be used by the companies jointly, not necessarily because of any agreement among themselves to do so, but solely because they believe them to be right rates.

There has been formed by company members of the National Association of Casualty and Surety Underwriters a steam-boiler and flywheel service and information bureau. The organization of this bureau is now nearly complete, and it is expected to be in full sway some time in September.

Ideal Automatic Float Valve

This valve is designed to automatically control the height of water in tanks and reservoirs and can be adjusted to maintain the water at any desired level. In the sectional view, shown herewith, the water enters the tubular-valve *A* at the inlet *L*. When the valve is closed



Ideal Float Valve

the pressure comes against the leather seat *B*, which can be renewed by removing the plug.

When the water in the tank lowers, the float *J* carries the end *M* of the lever *D* upward, which moves the toggle *C* with it. As the toggles *C* and *E* are attached the movement carries the valve *A* away from its seat and water will flow through the outlet *I*.

The float *J* is adjustable at *K* and can be operated at any angle. The valve passes through a stuffing-box *G*, containing square flax packing *H*. The valve is made in sizes from 1 to 2½ in. by the American Steam Gauge & Valve Manufacturing Co., Camden St., Boston, Mass.

The decline in shipbuilding during the five-year period between 1904 and 1909, according to the Census Bureau, is clearly brought out by the fact that for all classes of vessels of five tons and over there was a decrease, with the exception of motor boats, which formed a small part of the total number reported. The decline in the iron and steel branch of the industry is no doubt due to the decrease in government work done in private shipyards. The increase in the number of small boats constructed is perhaps the most noteworthy fact. Motor boats of more than five tons increased 189.9 per cent. in gross tonnage from 1904 to 1909. The number of small power boats of less than five tons launched by private establishments in the shipbuilding industry was 8577 in 1909, as against 1687 in 1899, an increase for the decade of 408.4 per cent. Practically all the boats of this tonnage are fitted with internal-combustion engines.

Large Power System in South Africa

SYNOPSIS—The plants of the Victoria Falls and Transvaal Power Co. deliver over five million kilowatt-hours annually to the great mining industries in that section. About fifty thousand horsepower is delivered by compressed-air transmission, the greatest distance in this case being eighteen miles, the remaining power is transmitted by high-tension current.

Notably important are the installations of the Victoria Falls and Transvaal Power Co. in South Africa which, after but four years of operation, have reached an annual delivery of five million kilowatt-hours with the not far distant probability of ten millions. In load capacity they rank not only first among public power plants for industrial service but are the only ones delivering a large part of the energy great distances in the form of compressed air; this service alone amounting to 50,000 hp.

From a report of an investigation made in 1905 as to power needs, the gold fields of Witwatersrand extending east and west from Johannesburg a total distance of some 50 miles with an average width of about six miles undoubtedly comprise one of the greatest industrial districts on earth. The number of mines in operation on June 30, 1905, was 66 and the machinery exceeded 200,000 hp. Of this power production only about 25,000 hp. was electric and practically all the rest was steam. An average for 24 mines reported 1.62c. per i.hp.-hr. as the cost of power, which, expressed in electrical units, assuming a steam-engine efficiency of 85 per cent., shows a cost of 2.52c. per kw.-hr.

The figures showed that the operating conditions peculiar to Witwatersrand, more than elsewhere, urged the centralization of power production. The great consumption density and the otherwise hardly attainable high load factor were in this case forceful elements in favor of distribution from a large power house.

First of all a design was worked out for the transmission of compressed air and electricity. The main plant was designed for 70,000 hp. and in addition to the Eckstein mines was to serve those of the Consolidated Goldfields group. At the same time the current price was estimated at 0.9c. per kw.-hr.; whence it would have paid to have supplanted already existing steam plants by electric drives. The air was to be compressed in a large central compressor plant and delivered to the mines through a system of piping under a pressure of about 120 lb. The electric long-distance transmission system was to be overhead.

The argument for this plan was that the direct transfer of compressed air would yield a higher efficiency than electric transmission for the operation of individual compressors by means of electric motors at each mine.

Coincident with the efforts of the Allgemeine Elektricitäts Gesellschaft, though independent thereof, the Chartered Co. also took up the question of power supply to the Rand territory with a view to utilizing the vast power possibilities of the Zambesi at Victoria Falls. To this end rights were acquired from the Chartered Co. to erect at the Victoria Falls site a power house with a capacity of 250,000 hp. The need of an exhaustive investigation into the means to be taken to make it economically and technically possible to transmit this service over the distance of 680 miles, led to the formation of a committee of experts which included Blondel, of Paris, Gisbert Kapp, of Edinburgh, Lord Kelvin, of London, and Tissant, of Basel.

Though this project was not carried into effect, the experts recommended a high-tension three-phase transmission having a constant-current intensity and a variable voltage; the service to be thus varied by means of automatic regulation of the pressure, the upper limit of which was placed at 100,000 volts. The disadvantage of constant copper losses, particularly noticeable at light loads, was negligible because a load factor of over 80 per cent. could be counted on and because there was at hand a water power otherwise unutilizable during such light loads.

With the incorporation of the Victoria Falls Power Co. in 1905, the Allgemeine Elektricitäts Gesellschaft assumed the development of the different projects and all construction. Two power houses with a total capacity of 18,000 kw. were decided on as the initial installation. The smaller plant, with two 3000-kw. units, was to be erected at Brakpan in coöperation with the Rand Central Electric Works and the other with four 3000-kw. units at Simmerpan, because only at those points two large artificial ponds were available for the necessary water.

The Brakpan and Simmerpan Works

The Brakpan works are situated in the extreme easterly part of the Rand. The extent of the installation was restricted at the start by the water supply for condensing purposes. The plant consists of two turbo-generators of 3000 kw., which were originally wound for 10,000 volts, but later were rebuilt for low voltage and transformer inclusion because the high-tension winding was too much endangered through the heavy atmospheric discharges.

There are eight B. & W. marine-type boilers with a normal delivery capacity of 17,000 to 22,000 and a maximum of 30,000 lb. of steam per hour at a temperature of 600 deg. F. Green economizers and artificial draft on the ejector principle are provided with two boilers to a stack. The efficiency attained in operation lies between 77 and 80 per cent. and a preliminary test made in Glasgow showed 83 per cent. The blowers are driven by direct-connected electric motors and the draft is regulated by dampers. The natural draft is sufficient for about 40 per cent. of the boiler duty. For fuel, dust coal is used with a small admixture of fine coal; the heat value of this fuel being from 9000 to 10,800 B.t.u. The voltage is stepped up to 40,000 volts and the current is transmitted exclusively by overhead systems.

At the Simmerpan works there are two boiler houses, each with eight boilers of a unit hourly capacity of 19,800 lb. Each boiler house serves as an initial installation, two turbo-generators of 2000 kw. capacity. In the steam lines the ordinary separators did not prove sufficient, inasmuch as at first through frequently occurring short-

*Translated and abstracted by W. F. Monaghan from a contribution in "Zeitschrift des Vereines Deutscher Ingenieure," by Dr. G. Klingenberg.

circuits water was carried over to the turbines. They were on that account displaced by receiver separators which serve not only for their intended purpose but, at the same time, act as heat reservoirs to reëvaporate the entrained water.

It may be noted that the two-generator booster used to charge the battery is driven by a synchronous motor which is operated by the battery in case of interruption of the power plant and is employed to actuate the auxiliary motors. To this end the battery is designed for short periods of heavy load. This arrangement has proved well justified, serving to operate the auxiliary machinery when other sources of current were not available.

Midway between Brakpan and Simmerpan is situated the main switch and transformer station, or substation, and through which pass both the 40,000-volt lines. The voltage is there stepped down to 10,000 and, as at Brakpan and Simmerpan, there are local distribution systems.

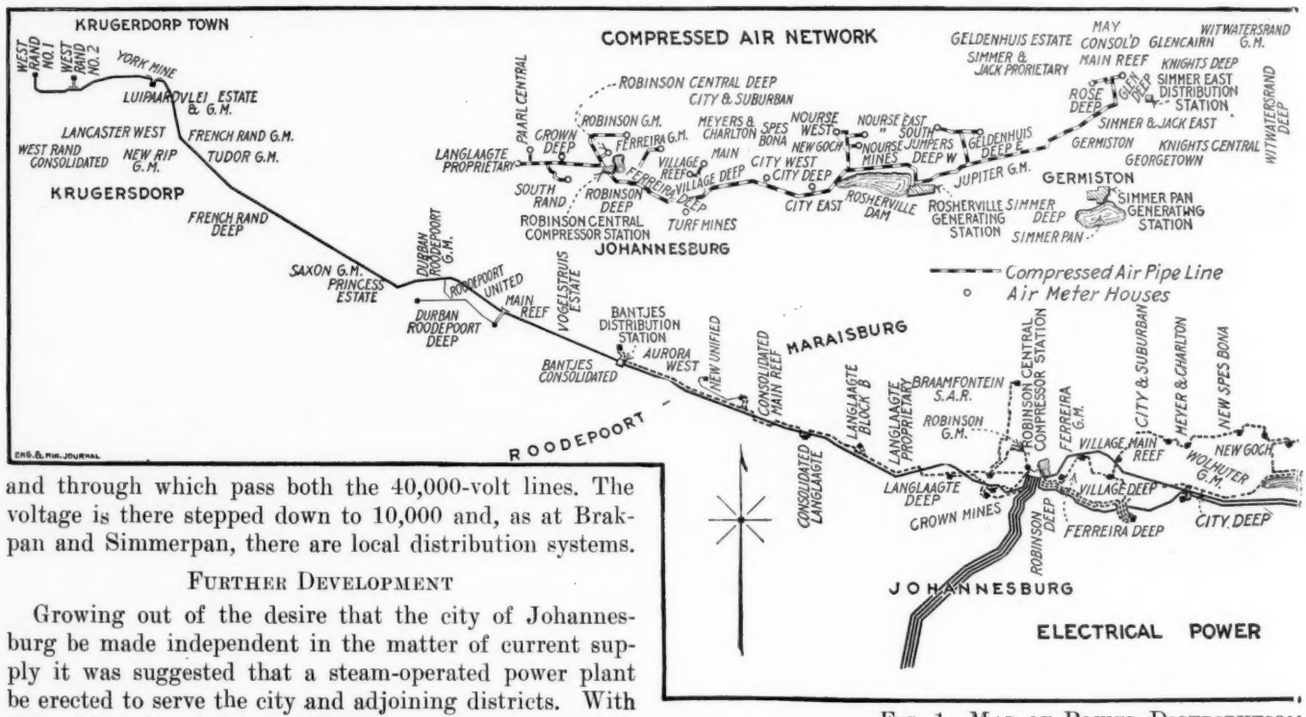


FIG. 1. MAP OF POWER DISTRIBUTION

FURTHER DEVELOPMENT

Growing out of the desire that the city of Johannesburg be made independent in the matter of current supply it was suggested that a steam-operated power plant be erected to serve the city and adjoining districts. With this object in view, negotiations were conducted with different mining companies and, while the Victoria Falls Power Co. prevented the accomplishment of a contract with the city, the plan was successful in that the largest of the mining interests, the Eckstein group, entered into an agreement for current delivery—probably the most important of its kind ever consummated with a single consumer. Outside of a guaranteed minimum yearly consumption of 80 million kw.-hr., the Eckstein concern pledged itself for its total power needs, and, in addition, all machinery should be ready for electric operation by the time the new power plant was finished.

About 40 per cent. of the service was to be through compressed air. To arrive at this air service, investigations were made, and in particular the conversion factor for one kilowatt of air service was determined from the formula

$$1\ kw. = \frac{1}{n}\frac{g}{1000}\,p_o v_o\,log.e\,\frac{p}{p_o}$$

as a function of volume, pressure and temperature. The constant $\frac{1}{n}$ was to be determined by efficiency tests of existing compressor plants. The price agreed on for a kilowatt-hour of electricity was 0.89c. and for a kilowatt-hour of air 1.33c.; subject to a decrease if the freight charges on the coal were lessened.

The contract with the Eckstein mines was later extended to 20 years and the guaranteed minimum current consumption was raised from 80 to 130 million kw.-hr. per annum.

Lacking government consent for the introduction of foreign current into the Transvaal, withheld for the protection of the coal-handling interests, the utilization of the Victoria Falls was impossible and the corporate name was changed to the Victoria Falls & Transvaal Power Co. A new contract was entered into with the Allgemeine Elektricitäts Gesellschaft for the construction of new power houses with a service capacity of 84,000 kv.-a. in steam turbine units and 40,000 hp. in air compressors, and the necessary overhead transmission lines for 40,000 and 10,000 volts, an underground cable system for 20,000 volts and an extended piping system for 128 lb. pressure. Meanwhile, through the taking over of two new mining companies, the power need of the Eckstein group had increased to 320 million kw.-hr. To be added thereto was the very considerable power consumption by the Goldfields and Albu groups which had, in the meantime, signified their readiness to be included in the service, so that to begin with, a consumption of about 500 million kw.-hr. could be counted on.

The coal found in the Rand territory lies at moderate depth and is of low grade, though when mixed with the better grades it is available for use with the chain-grate stoker. The most important coal deposits are in the Witbank-Middleburg district, about 200 miles east of Johannesburg. The coal is good and has a heat value of 11,500 to 12,600 B.t.u.

ROSHERVILLEDAM AND ROBINSON CENTRAL PLANTS

The power plant at Rosherville dam consists at present of 32 boilers of 33,000 lb. hourly evaporative capacity

each, or a total of 1,056,000 lb. per hr. The engine house contains five turbo-generators, each of 12,000 kv.-a. capacity at 5000 volts and six 4000-hp. turbo-compressors. The exhaust from the auxiliary turbines is discharged into the second stage of the main turbines and the exhaust from the turbines operating feed pumps is used for heating the feed water.

The same provision is made here as in the other plants for the operation of the auxiliaries by use of the synchronous motor of the storage-battery generator set; the auxiliary transformers being automatically disconnected from the busbars on the resumption of the main current supply.

The Robinson Central Works form a subsidiary installation about five miles west of Roshervilledam. It is not a generating station and current is supplied to it from Roshervilledam by four 40,000-volt overhead conductors and from Vereeniging by three 80,000-volt conductors and stepped down as needed.

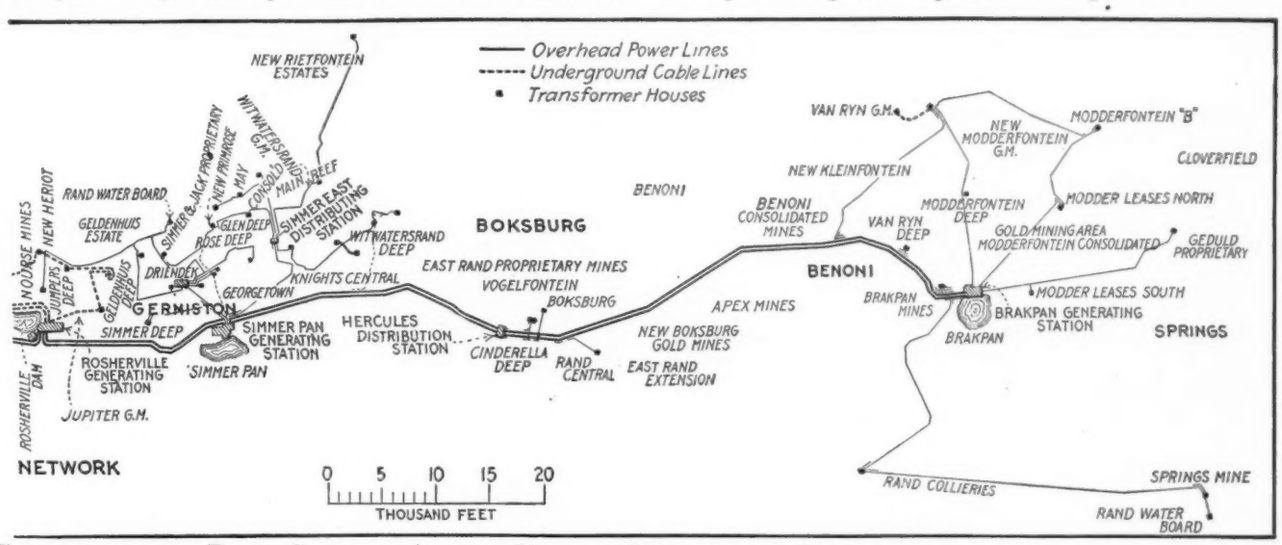
The air is supplied by turbo-compressors of which six 4000-hp. units comprise the initial installation. Each unit is made up of two parts of two cylinders each and each part is operated by means of a direct-connected, 2000-hp. synchronous motor, this method of drive being preferred because the load factor of the whole system is thereby improved. An installation of special motor-generator sets is provided for starting the compressors; the motors of these sets being synchronous.

In starting, the generator of a set is first electrically connected with one of the motors of the compressor unit and both the generator and motor are then fully excited; upon which the generator is slowly set in motion. The synchronous motor of the compressor is carried along with it, the suction valve being closed and the compressor running light, and after a speed of 3000 r.p.m. has been reached it is cut into the system, in the usual way for synchronizing, and the starting generator is then thrown out. This procedure is repeated for starting the other motor of the compressor unit. The service necessary for the starting of the individual halves of the compressor units lies between 400 and 600 kw.

It is important that the piping system should be supplied with the cleanest possible air, and good filtering plants are installed. A special pumping plant provides the water for cooling the compressors, the supply being drawn from the Robinson pond and delivered through a duplex coke filter.

Of the 320 million kw.-hr. for the Eckstein group, about 40 per cent. was to be furnished in compressed air. From the determined load factor, and with inclusion of the 25 per cent. reserve on call, this quantity of air indicated a mechanical duty of around 50,000 hp. The maximum transmission distance for the air is a little over 18 miles. Previous to this installation the compressed-air plant then in operation at Paris had a duty of approximately only 8000 hp., and the largest reciprocating compressor built for the pressure in question had a capacity of but 1500 hp. The designing of rotary compressors was still in the early stages of development and satisfactory results were at hand only for small loads and air lines of only approximate measurements, for such pressures had not previously been used. Even the pipe couplings, required over three months in their development, as the Paris type had proved unsuitable. These couplings had to meet the following severe requirements.

(a) They must serve as stuffing-boxes as the pipe lines are exposed to great temperature changes.



Systems on the Rand, Showing Air and Electric Transmission Lines

(b) They must be easily taken apart to permit of pipe removals.

(c) They must allow direction changes of 5 to 10 deg., that the line may accommodate itself to surface alignment.

(d) They must, under these conditions and with pipes of a maximum diameter of 24 in. remain tight under a pressure of 128 lb. per sq.in.

The measuring appliances are called on to reliably care for a yearly service of more than a hundred million kilowatt-hours of which the money value for that time is represented by $1,190,000. The necessity for their accuracy and reliability is best measured by the statement that an error of 1 per cent. means $11,900.

In many cases the conditions which governed the installation of the air system were applicable to the electric system, inasmuch as all the Eckstein mines, besides the transmitted electrical energy, used compressed air at the same time, and thus the pipe lines and the electric conductors could often be laid in the same trenches. The systems are in most part buried, overground laying, on concrete columns or posts, being done only on crossing

valleys and marshes, and at such places are covered with corrugated iron to protect the piping against undue heating by the sun. The length of the single line is eight miles of 9-in. to 24-in. pipe. For packing for the stuffing-boxes contour rings of extra-good rubber are used; these corresponding in section to the inside form of the boxes in which they are used. A maximum leakage loss of 2 per cent. had to be guaranteed, and the actual loss from that cause has been found to be somewhat less than 0.5 per cent.

The air service to the different consumers is measured in kilowatt-hours, figured on an isothermic basis, to which end a special meter is installed at each mine which automatically records the work delivered. As air-measuring appliances of the gas-meter type, in which the indicating mechanism is influenced by pressure and temperature, would have been of unusual dimensions and complex, it was decided to resort to measurement by means of nozzles of the Venturi design to which were added recording devices taking into account the variation of pressure and temperature. Each manometric and thermometric spring, governed in its movements, respectively, by pressure and temperature, actuates a logarithmic cam; the movements of both are added by means of gearing; the sum is transferred to an anti-logarithmic cam, and the indicating mechanism thus gives the product of both movements. These meters have proved to be very satisfactory under all operating conditions.

❖ ❖

A New DeLaval Velocity-Stage Turbine

SYNOPSIS—The turbine consists of two regular DeLaval wheels with a row of reversing blades between. The reducing gear is still retained.

❖

For twenty years the DeLaval Steam Turbine Co. has built, and still continues to build, its original high-speed single-stage gear-reduction turbine, since this arrangement offers certain advantages in promoting efficiency by allowing the buckets to travel at approximately the proper velocity relatively to the velocity of the steam

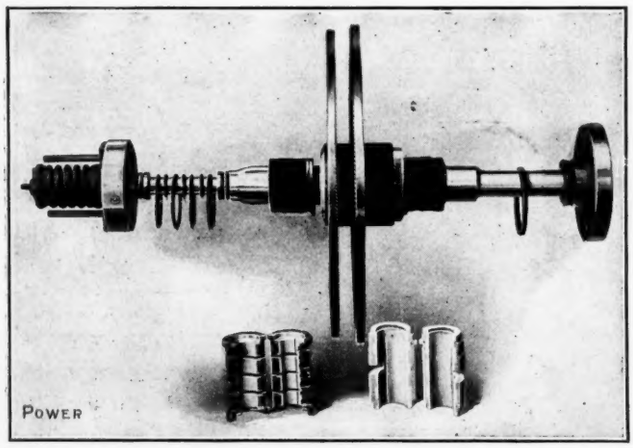


FIG. 1. COMPLETE ROTATING MEMBER AND BEARINGS OF DELAVAL CLASS C TURBINE

jet, while permitting of driving generators, pumps and blowers, and of rope or belt drive without sacrificing the efficiency or reliability of the driven machine by overspeeding. The single-stage turbine, however, has definite limitations as to capacity, that is, with a given-size wheel and speed of rotation, centrifugal force sets a definite limit to the allowable length of the buckets. To evade this limit, that is to build turbines of larger size, the engineers of the DeLaval Co. some time ago introduced pressure stages, as in the new DeLaval pressure staged multicellular turbine described in the June 4, 1912, issue of POWER, although still retaining the reduction gear as the best means of effecting the compromise between the best turbine speed and the best speed of the driven machine. Only enough stages are introduced to reduce the speed of the turbine sufficiently to allow of lengthening the blades to secure the desired capacity, the remainder of the speed reduction being left to the gear. Inasmuch as there are many services, such as in driving small pumps and blowers, exciters, etc., where the additional cost and complication of gears and pressure stages are objectionable, and where high steam economy is not so important, since the turbine may exhaust into open feed-water heaters or into heating systems, the DeLaval Co. has perfected a line of velocity-stage turbines.

Two DeLaval wheels made in the regular DeLaval way by inserting the buckets as shown in Fig. 2, are

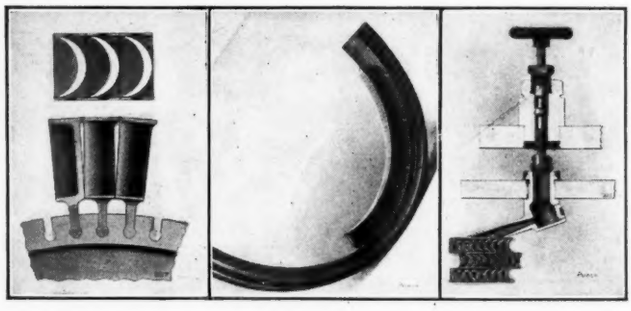


Fig. 2 Fig. 3 Fig. 4

FIG. 2. METHOD OF MOUNTING BUCKETS
FIG. 3. STATIONARY GUIDE VANES
FIG. 4. CONTROLLING VALVE, NOZZLE, BUCKETS AND GUIDE VANES

run beside each other as shown in Fig. 1 upon the same shaft, the one further from the nozzle having longer blades to allow for the passage of the same volume at a diminished velocity. A row of similar blades set into a steel ring, as shown in Fig. 3, is placed between these two wheels so that the steam follows the course indicated in Fig. 4 as in the regular Curtis turbine. The high-pressure steam is admitted to the box on the side of the casing only, and only the lower-pressure steam after it has expanded through the nozzle has access to the interior of the casing. Each nozzle is controlled by a handwheel accessible from the outside as shown in Fig. 5, so that more or less nozzles may be put into action according to the service to which the turbine is to be put and the nozzles which are in play will be under the action of the throttling governor, the moving parts

of which are completely incased in the stationary casing. The usual emergency governor is of course included.

The buckets both of the rotor and stator are individually removable so that they can be quickly replaced and the ring carrying the stationary bucket constitutes

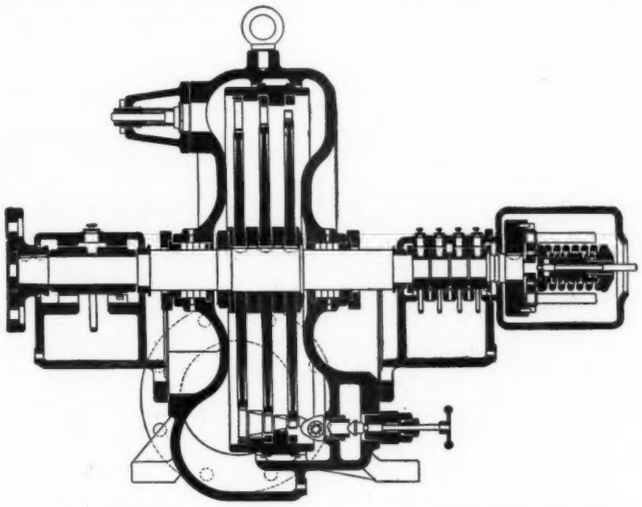


FIG. 5. LONGITUDINAL SECTION THROUGH "NC" TURBINE

an effective stop against the flying of pieces should breakage occur. The housing is divided horizontally and the top has no piping or other attachment, but is simply a cover which may be easily removed, exposing the working parts. The shaft is carried in two ring-oiled bearings (see Figs. 6 and 7), one of which is a thrust bearing by which the axial position of the shaft and the relations of the moving and stationary buckets are fixed. The bearing brackets are supported directly on the turbine casing and are separate from the stuffing-boxes.

Instead of carrying the two crowns of moving blades upon a single disk, as is usual with builders of the Curtis type, each row of moving blades is carried upon its own disk, which is thus subjected to the centrifugal force due to the mass of a single row. The turbine, in fact, consists of two regular DeLaval wheels with a row of reversing blades between them. Each part that can be worn or eroded is machined to limit gages and interchangeable so that it may be quickly and cheaply replaced. The only way in which high pressure could accumulate within the casing would be through the stoppage of the exhaust outlet. To guard against any accident from this cause, a relief valve is fitted to the upper part of the casing cover, as shown in Fig. 5. If the turbine is to be operated with superheated or high-pressure steam having a temperature of 450 deg., F., or over, the parts of the governor valve and safety-stop valve coming in contact with the high-pressure steam are made of steel.

Long experience with high-velocity steam jets has convinced the builders of the DeLaval turbine that the most satisfactory form of bucket to resist erosion is a drop-forging of metal having a high resistance to corrosion or erosion upon which the original scale, formed in the drop-forging process, has been allowed to remain. The buckets of the present turbine are made of nickel bronze by this process and are inserted in the rim of the wheel by bulb shanks fitted into slots milled and bored in the rim transversely to the plane of the wheel, as shown in Fig. 2, a mode of attachment which has been thoroughly tried out in the DeLaval turbine for years. The guide blades are similarly formed and secured.

With ordinary noncondensing operation the packing of the stuffing-boxes is a simple matter, as there is practically an equal pressure inside and outside of the casing. Where condensing operation is contemplated the provision of efficient packings about the shaft becomes an important factor and in the present turbine a soft packing has been adopted with provision for steam or water sealing. The turbine in this form is available in capacities of from 1 to 750 hp.

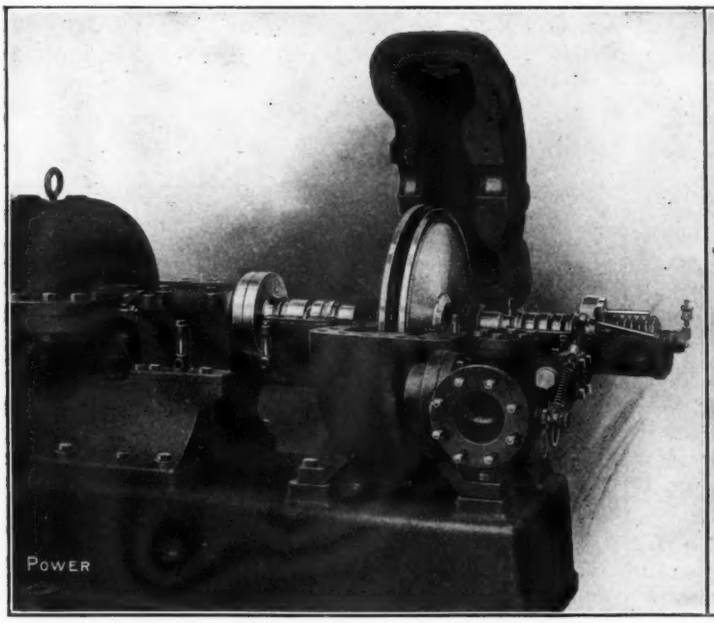


FIG. 6. THE TURBINE WITH BEARING CAPS AND COVER LIFTED

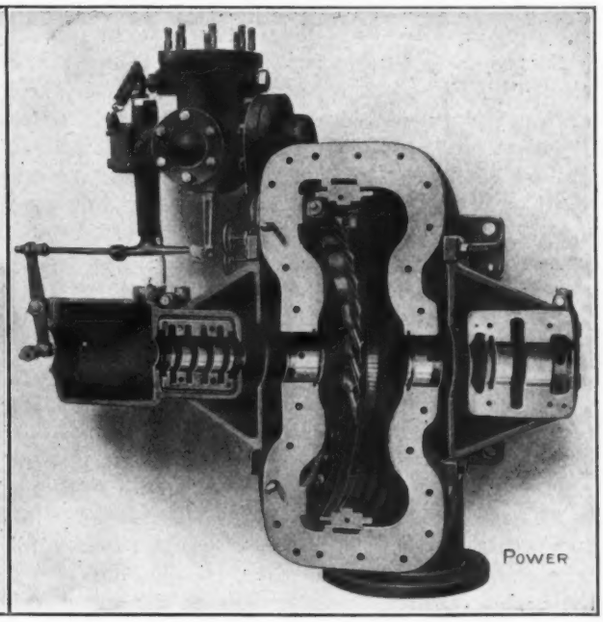


FIG. 7. TURBINE CASE AFTER ROTATING PARTS AND BEARINGS HAVE BEEN REMOVED

Elliott Twin Heater

Engineers have frequently encountered operating conditions such that a twin heater would have been a valuable adjunct to the plant equipment had it been installed, which would have enabled one-half to have been cut out for cleaning, etc., while the other half was carrying the load. The Elliott Co., 6908 Susquehanna St., Pittsburgh, Penn., has recognized the advisability of such a heater, and is now manufacturing what is known as a twin heater, consisting of two heaters in one, comprising a heating chamber divided into two parts by a partition.

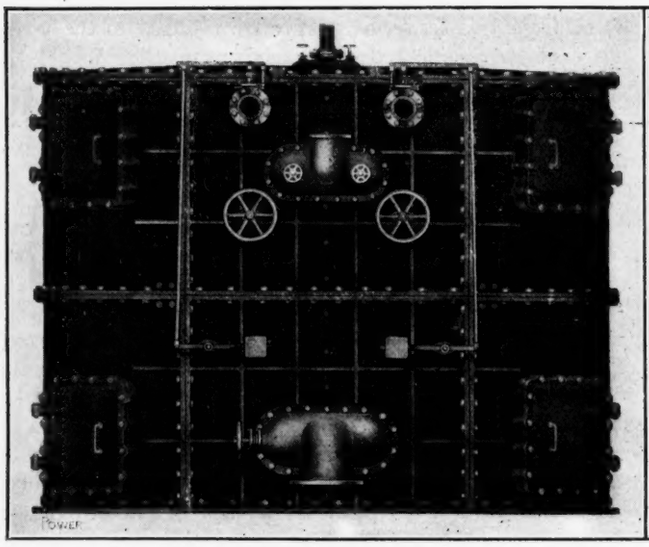


FIG. 1. FRONT ELEVATION OF TWIN HEATER

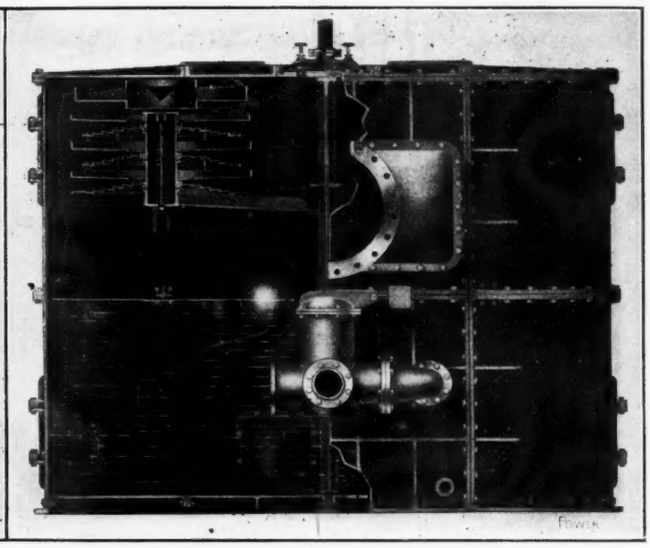


FIG. 2. HALF SECTION OF TWIN HEATER

It is so designed that either side can be operated independently, or both sides can be operated conjunctively. Each compartment has its own steam inlet, oil separator, cutout valve, pans, water inlet and outlet, overflow, etc. As each inlet and outlet is provided with a valve which is a part of the heater, it is only necessary to place it on the foundation and connect up the exhaust, feed-pump suction and blowoff lines. Fig. 1; a front elevation of a twin heater, shows the clean-out doors and the various connections. Fig. 2 is a rear view and half section of the heater.

As the complete valve equipment and connections form a part of the heater, it makes a compact piece of apparatus, and reduces the cost of piping.

In operation the steam enters the main inlet nozzle which communicates with the two inlet nozzles on the two sides of the dividing wall, where it comes in contact with the combined valve and separators and precipitates the entrainments into the overflow box below. If the heater is carrying back pressure a trap is attached to the two overflow boxes and serves as a means for sealing the openings; at the same time it automatically discharges the condensation water. The trap also relieves the heater of surplus water, should the height of the normal water level be exceeded.

The operation of the float-controlled inlet valve, pans, etc., is identically the same as that described for the cylindrical heaters on page 290 of the Aug. 26 issue. The hot-water outlet is hooded and vented to the steam pipe extending above the top of the water level; the two outlets communicating with the main pump section are controlled by check valves. The heater is vented through the outlet on top which communicates with both sides through openings controlled by valves.

The advantage of this heater is that it is adapted to central stations, office buildings and power plants, where the operation is continuous and where there are light-load periods, during the day or night, when one side can be cut out and cleaned, at the same time maintaining the maximum temperature of the water going to the boilers. All controlling valves are accessible, as they are part of the heater and are especially designed for the purpose intended. The heater is made of cast iron and is capable of withstanding 15-lb. working pressure.

The pump-suction connection extends downward and is provided with a flange. Each side of the heater has an independent outlet communicating with a common chamber adjacent to the main outlet to the pump suction. The outlets to both sides of the heater are protected by check valves opening in an outward direction, as shown in Fig. 3. The main outlet is also provided with a sliding gate valve, Fig. 4, for completely isolating either side. This valve is so arranged as to shut off either side, making it absolutely independent of the other, but is rarely used except in emergencies as in the event of the

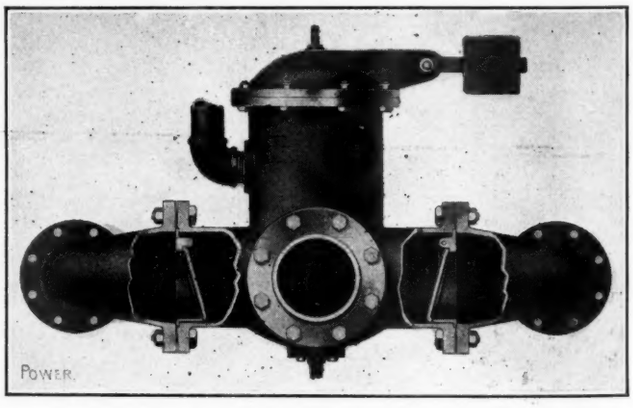


FIG. 3. SUCTION CHECK VALVES

check valve sticking or leaking. The illustration is a top view of the hot-water outlet, showing the valve and vented hoods.

Fig. 5 shows a vertical section of a twin heater and a general arrangement of cutout valves, trap, overflow box, pans and pump suction, also the water supply. The entrainment coming from the separator, also from the

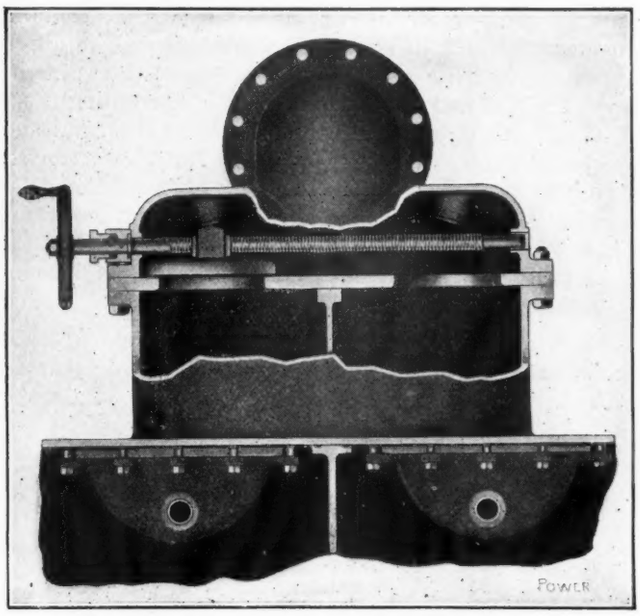


FIG. 4. SLIDING GATE VALVE

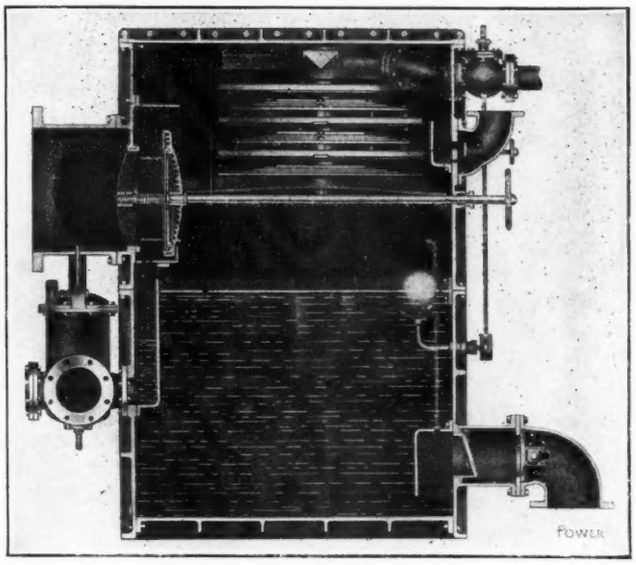


FIG. 5. SECTION SHOWING CUTOUT VALVE, TRAP, OVERFLOW BOX, PANS, ETC.

overflow from the heater, is controlled by a float-actuated trap connected to the outlets and the two overflow boxes located below the steam inlet.

The connection between the overflow outlets and the trap is provided with a check valve opening toward the trap. The trap is vented to the main inlet nozzle. When one part of the heater is out of service, the water in the trap chamber alone, or aided by the back pressure on the opposite side, will cause the check valve on the idle side to remain tight. When it is desired to cut out one side of the heater with this arrangement, it is only necessary to close the cutout valve.

If the heater is used on a heating system the returns are admitted through a single inlet nozzle mounted on the front wall. This nozzle has two valve-controlled branches communicating one to each side of the heater. The return inlets are water sealed and placed in the steam chamber, and the water dropping to the water level has its temperature raised should the incoming temperature be less than that of the steam in the heater.

Otis Elevator Controller-Parts Cabinet

In order to facilitate and quicken repair service in the event of unexpected breakdowns or worn parts on elevator controllers, a controller-parts cabinet for the convenience of engineers is made by the Otis Elevator Co., Eleventh Ave. and Twenty-sixth St., New York City.

It is made of steel, and contains all essential parts of the type of controller furnished with the elevator machine installed. By referring to the descriptive catalog in the box the engineer can determine at a glance just the part needed to replace the broken or worn mechanism. If any of the parts are removed from the cabinet, duplicate parts can be ordered immediately to replace them so that the cabinet will always be complete.

The advantages of having one of these cabinets in the engine room are that repairs can be made on the spot, elevator service will not be impaired, and there is always at hand a remedy for any controller trouble.

Automatic-Release Pen Lifter

This attachment can be attached to any Foxboro improved recorder. It is a simple device, consisting of a German-silver strip mounted on a special holder, inserted under a screw-head which holds the chart disk. A slight pressure on a small lever brings the strip up against the pen arm and lifts the pen from the chart. Friction holds it in the raised position, thus giving the operator free use of both hands for removing the used chart and supplying a new one. When the door is closed, the pen arm is automatically released and the pen returns to its marking position on the chart. This automatic feature makes it impossible for the operator to forget and leave the instrument out of commission.

The device, which is manufactured by the Industrial Instrument Co., Foxboro, Mass., eliminates the necessity of handling the pen arm, with the possibility of affecting the adjustment, due to a slip or accidental strain. It also prevents accidents commonly resulting in spreading ink where it does not belong and is not desired.

Largest Fuel Consumer—The Pittsburgh district of Pennsylvania is the largest consumer of fuel in the world, and in magnitude of coal traffic it is also preëminent. In population Pittsburgh ranks fifth among the cities of the United States, having as "Greater Pittsburgh" only about one-sixth that of Greater New York, but in the consumption of coal alone Pittsburgh nearly equals that of the largest city in the country. It is estimated (no accurate data being available) that Greater New York consumes between 18,000,000 and 20,000,000 short tons of coal annually. The Pittsburgh district in 1912, according to Edward W. Parker, of the U. S. Geological Survey, consumed 17,721,783 tons of coal and about 5,000,000 tons of coke, or a total of about 22,700,000 short tons, over 10% more than all the boroughs of Greater New York. Pittsburgh also consumes millions of cubic feet of natural gas.

ELECTRICAL DEPARTMENT

Aluminum-Cell Lightning Arrester

By John A. Randolph

The function of any lightning arrester is to accomplish for the electric circuit what the safety and hydraulic relief valves do for mechanical apparatus, namely, the prevention of a rise in pressure above a safe limit. In so doing, it protects the apparatus near it from the disastrous effects of abnormal currents and strains due to the excessive voltages caused principally by lightning.

There are various types of arresters, the choice depending upon the nature and value of the apparatus to be protected, the service performed by the circuit, the working voltage, the kind of current, and, to a certain extent, upon the locality. A type which is used extensively on high-voltage systems consists of the electrolytic or aluminum cell arrester. It consists essentially of a series of aluminum trays, or cone-shaped receptacles, an electrolyte, a quantity of oil and a containing tank.

The receptacle or plate elements are designed to hold the electrolyte and to fit into one another concentrically with a predetermined clearance. The top receptacle is connected to the line through a horn gap, and the bottom one connects to the ground. Various solutions may be used as the principal ingredient of the electrolyte, some of which are dilute sulphuric acid, bichromate of potash and ammonium phosphate.

The action of the arrester depends upon the fact that when an electric current is passed through the series of electrolytic cells, composed of aluminum plates and a suitable electrolyte, a thin film of aluminum hydroxide is formed upon those parts of the plates exposed to the electrolyte. A characteristic of this substance consists in its acting as an insulator or dielectric up to a certain value of the voltage known as the critical value. At potentials above this point, it breaks down and allows the current to flow freely to ground as long as the pressure remains above the critical value. When the voltage drops to this point, the film regains its insulating property and resists the flow of current as before.

As commercially constructed, the receptacles and electrolyte are placed in a steel tank which is filled with oil to a depth sufficient to completely cover the receptacles.

One form of arrester is shown in Fig. 1. The aluminum plates in this case are in the form of circular trays and are placed in a vertical stack in the center of a round steel tank. For convenience in handling, the trays are grouped in sections, each section being sufficiently light in weight for a man to handle. The trays of each section are held together by treated wooden tie-rods placed outside the trays. The sections are held in place by two vertical wooden guides which fit loosely into two slots in the top and bottom clamps. A clearance of about ¼ in. is maintained between the trays by porcelain spacers. The trays are filled with electrolyte to about the depth shown, a quantity being used which is sufficient to permit every tray to make good contact through the electrolyte with its neighbor. The containing tank is made of steel and is large enough to afford sufficient clearance to prevent arcing across between the trays and the tank on discharge. The intervening space is filled with oil which completely covers the trays and electrolyte, and which does not mix with the electrolyte, owing to the higher specific gravity of the latter. By keeping out the air, the oil prevents evaporation of the electrolyte. It also aids in the dissipation of the heat generated by a continuous discharge, owing to its tendency to circulate from points of high to points of low temperature. In addition to the functions already described, the oil serves as an effective insulation between the trays and the sides of the tank. The conductor connected to the contact plate at the top of the tray stack extends through a porcelain insulator mounted in the cover of the tank and is joined outside the tank to a cable or wire connecting with the horn gap.

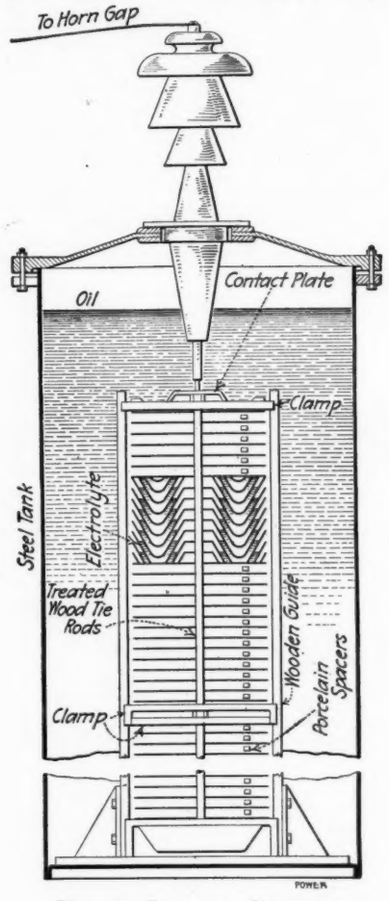


Fig. 1. Partial Section through Cell

The number of aluminum receptacles used in an electrolytic arrester depends upon the normal or working voltage of the circuit protected. On alternating-current lines one receptacle is used for each 275 effective volts. With direct current, one receptacle is used for each 350

volts. The critical or discharge voltage is 300 volts per receptacle for alternating currents and 420 for direct-current circuits.

Aluminum Receptacles

These should be of a contour such as to permit the free circulation of oil and to allow all bubbles formed

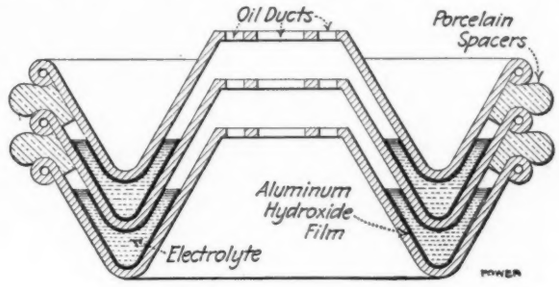


Fig. 2. Detail of Trays

in the electrolyte to pass off without collecting anywhere about the receptacle. For this reason, the receptacles are so designed that their surfaces are as smooth as possible and free from ledges and pockets which would collect bubbles or retard the proper circulation of the oil.

The form of receptacle used in the arrester of Fig. 1 is shown to a larger scale in Fig. 2. It will be observed that the receptacle is made into a form of a tray. Holes or ducts are provided in the central portion for the oil circulation.

Horn Gaps

An inherent quality of the aluminum-cell arrester is that when connected to the line a current will flow through it of a magnitude depending upon the state of the hydroxide film, the receptacles and the electrolyte. It is also dependent upon the resistance, if any, which is used in series with the arrester. If a resistance is used, the current can be made very small. A current, however, even though small, flowing continuously through the arrester, has a deteriorating effect upon the arrester as a whole. An electrolytic action takes place between the aluminum receptacles and the electrolyte which results in a gradual deterioration of the receptacles and a wasting away of the electrolyte. The heat formed also enhances the harmful effects of the continuous charge. On account of the disadvantages of a continuous flow of current through the arrester, it is the general practice to place a spark gap or horn gap, as it is more commonly called, between the arrester and the line, thus leaving the arrester open-circuited at all times when not charging or discharging. There are also two other results accomplished by the use of the horn gap: Firstly, it acts as a disconnecting switch whereby the arrester may be easily disconnected from the line for cleaning, inspection and repairs; secondly, it can be used as a switch for connecting in the arrester for charging.

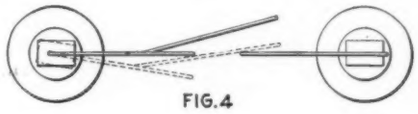
A form of horn gap commonly used on high-voltage lines is shown in Fig. 3. The insulator *A* carrying the horn *C* is mounted upon a pin *D*, which is so arranged that it can be easily turned by the arm *H;* the insulator *B* carrying the horn *E* is stationary. Fastened to the supporting arm of the horn *C* is a copper strip. Under normal conditions the two horns occupy the position shown by the heavy lines in Fig. 4. When it is desired to charge the arrester, the horn *C* is turned by the handle *H* to the position shown by the dotted lines, thus bringing the copper strip *F* into contact with the horn *E*. This action shortcircuits the horn gap and thereby subjects the arrester directly to the line voltage, causing a charging current to flow.

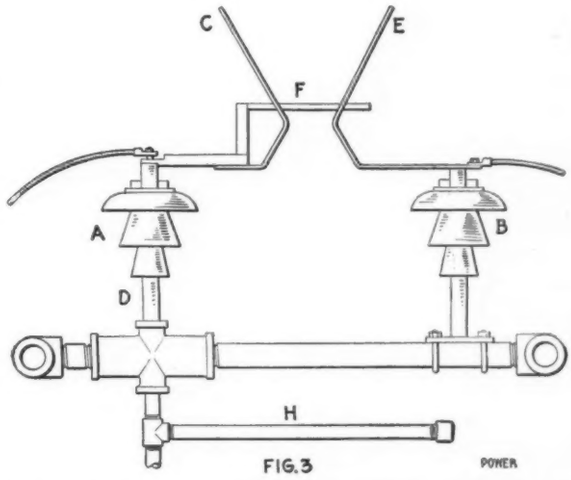
Charging Resistances

Oftentimes arresters are used under conditions such that it is desirable to regulate the charging current to prevent it from being excessive and thereby affecting the equilibrium of the system and injuring the aluminum receptacles as well. This is accomplished by arranging a resistance at the horn gap in such a manner that while charging, it is connected in series with the arrester and the main line.

Charging

The process of charging consists in forming the film of aluminum hydroxide. When once formed it will not last indefinitely, but is gradually dissolved by the electrolyte and, unless regularly replenished, will soon completely disappear, leaving the arrester temporarily useless. For this reason it is necessary frequently to rebuild or replenish the film. This consists simply in allowing a current to flow through the cells and electrolyte by connecting the arrester to the line either directly or through a resistance. The electrolytic action thereby established between the aluminum receptacles and the





Figs. 3 and 4. Showing Elevation and Plan of Horn Gap

electrolyte causes a new film to replace that which has been dissolved. The length of time required for a charge is ordinarily very short, a period of not more than 30 sec. being sufficient under normal conditions.

The intervals between charges depend upon the kind of electrolyte used, and upon the temperature. With the more common electrolytes, a daily charge is necessary. Some electrolytes are made, however, which require charging but once a week. The difference in the time between successive charges for the various kinds of electrolytes is due principally to the difference in the

resistances of the solutions. In those requiring charging but once a week, the resistance is sufficiently high to prevent an excessive rush of current at charging which would otherwise take place as a result of the dissolution of the film. With the electrolytes requiring more frequent charges the resistance is much lower, making it therefore inadvisable to allow more than a day to elapse between charges. The high resistance electrolytes, however, have the disadvantage of lowering the discharge rate of the arrester and are therefore not as desirable nor as generally used as those of low resistance. The temperature of the electrolyte is also an important factor inasmuch as the film will be more rapidly dissolved at high temperatures than at low. For this reason more frequent charges are necessary in warm weather than in cold. The electrolyte freezes at a temperature of about 20 deg. F., the effect of freezing being a lowering of the conductivity with a consequent lessening of the freedom of discharge and a lowering of the efficiency.

If, when an arrester is first installed, a period of more than two days has elapsed since charging, or, if already in service, an interval of twice its normal charging period or longer has elapsed since its last charge, it is best not to subject it to the full line voltage at first. This is because, owing to the abnormal dissolution of the film which has taken place, the resistance of the latter will be so low as to permit an excessive rush of current, resulting not only in disturbing the equilibrium of the system, but in overheating and injuring the cells and their connections. To prevent this contingency, arcs should be started across the horn gaps at half normal line voltage. After momentarily making and breaking the arcs ten or fifteen times, the potential should be raised to three-fourths normal, and the same operation repeated. The full voltage can then be applied by a few momentary flashes across the gaps, after which the arrester is ready for service.

Frequently it is not possible to obtain variable voltages for the foregoing procedure. In such a case, the fuses between the arrester and line should be replaced by a piece of No. 30 copper wire or a strand of lamp cord, after which the horn gaps should be short-circuited as in normal charging. The fuses will be blown every time the gaps are bridged until the film has reached its normal condition, after which these improvised fuses will no longer be blown. A bluish crackling static spark at the horn gaps will indicate a normal condition.

The number of separate cell stacks to be chosen for a three-phase alternating-current circuit depends primarily upon whether or not the neutral is grounded. It is necessary to consider the neutral in choosing the arresters because of the results likely to ensue from an accidental grounding of one of the lines. If the neutral is grounded and the oil switches are free to act instantaneously, only three cell stacks are necessary. This can be readily understood by reference to Fig. 5. It will be observed that when one phase *B* is grounded, the short-circuited current will take the direction of the arrows, thus affecting only the grounded phase *B*. On an ungrounded circuit, however, the short-circuited current, under the same conditions, would take the direction shown in Fig. 6, flowing through the arresters to the phases *A* and *C*.

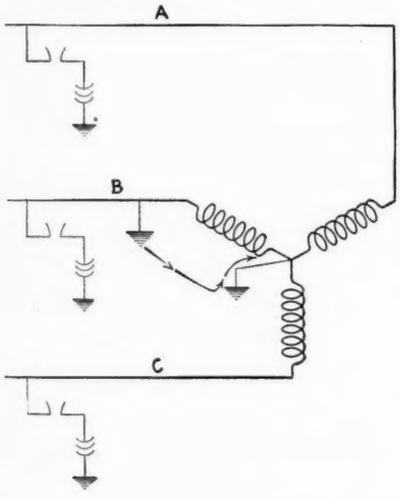


FIG. 5

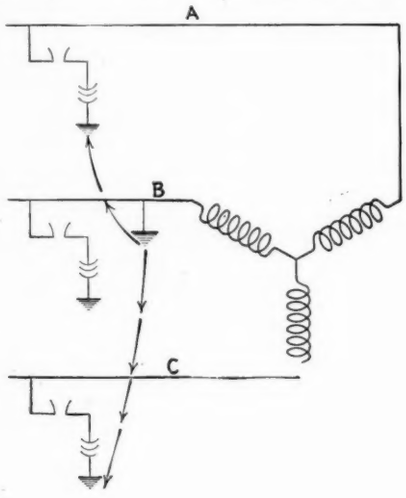


FIG. 6

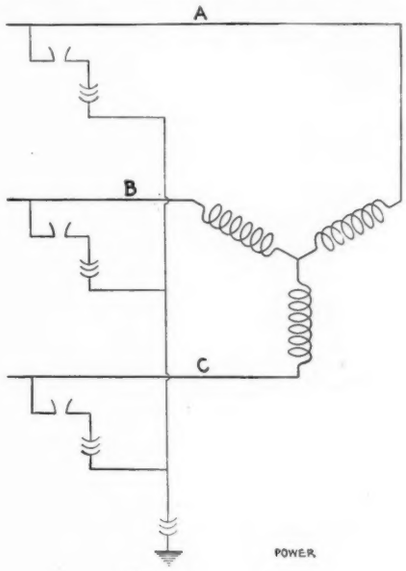


FIG. 7

On grounded systems, the arresters are chosen which are designed for only the normal working voltage of one phase. Under the condition shown in Fig. 6, however, the arresters on lines *A* and *C* are subjected to 1.73 times the normal or working voltage to which they would be subjected on a circuit with grounded neutral. This is due to the fact that in the customary Y-connected system the voltage between any two phases is 1.73 times the voltage between any line and the neutral. It is therefore apparent that on an ungrounded system a heavier arrester resistance must be inserted between the lines and ground than on the grounded circuit to protect the arresters against the excessive evaporation of electrolyte and wearing away of the plates that would result from the excessive currents due to grounded lines. This protection is accomplished by connecting the three main-line stacks to a common grounding busbar, as shown in Fig. 7, the latter being connected to a fourth arrester, which in turn is connected to the ground proper. By this means the arresters are permitted to discharge the heavy currents due to grounded phases, without being unduly overloaded. To secure the same result without the use of the fourth arrester, it would be necessary to increase the size of the other arresters.

GAS POWER DEPARTMENT

Comparative Cost of Gas and Steam Plants

By L. B. Lent

A very favorable opportunity to ascertain the relative costs of producing electric power with producers and gas engines and with boilers and steam engines has been afforded in a small lighting plant not far from New York City. For several years the station equipment consisted of two anthracite gas producers, two vertical three-cylinder gas engines and two 60-cycle two-phase 2200-volt alternating-current generators, one generator being direct-connected to a 100-hp. engine and the other generator belted to a 60-hp. engine. Each producer was rated at 75 hp. Twenty-four-hour service was furnished.

The load on the gas plant was small during the day and built up to a maximum during the lighting period in the evening, and in 1911 the peak became equal to the plant capacity.

The different characteristics of the two generators, which were of different make, and the difficulty of closely regulating the two gas engines made it almost impossible to operate these generators in parallel with any degree of assurance. Therefore, it was the practice to carry a part of the load on each machine by dividing the distribution circuits.

The rather unsatisfactory experiences incident to operating at maximum capacity led to a decision to build a new station on another site instead of increasing the capacity of the old station. This new station was accordingly built and equipped during 1911 with steam apparatus. The equipment consists of two 200-hp. horizontal return-tubular boilers, delivering their gases through an 80-tube economizer to a radial brick stack 125 ft. high. Steam is delivered to two 14x20-in. 200-hp. simple noncondensing engines at 150 lb. pressure. The engines are direct-connected to 60-cycle, two-phase, 2200-volt alternating-current generators, the exciter units being driven by belts from a pulley on the main shaft of each engine. The usual auxiliary equipment of a feed-water heater and duplicate boiler-feed pump is augmented in this station by a motor-driven fan for furnishing forced draft to the ashpits of each boiler.

The fuel supplied to the gas plant was anthracite pea coal, costing approximately $3.90 per ton, and that at present supplied to the steam station is anthracite No. 3 buckwheat costing approximately $3.50 per ton at the plant.

The present load and that which was carried during the year 1912 by the steam plant is substantially of the same character as that carried by the gas plant, except that it is larger during the entire 24-hour period. In fact, all of the operating conditions in the steam plant are so similar to those in the gas plant as to make a comparison of the cost of power a very fair one. In fairness to the gas plant, it should be stated that the operation was not as economical as was possible. An examination of the ash from the producers showed that considerable fuel passed through unconsumed and other conditions of operation made the fuel consumption higher than it should have been.

Costs

The first cost of the gas plant was as follows:

Building	$3,033.03	
Gas Power Equipment	11,537.64	
Electric Generators	2,490.08	
Accessory Electric Equipment	670.37	
Miscellaneous Eqlipment	81.38	
		$17,812.50
Cost of plant equipment without building		14,779.47

The rated capacity of the gas plant is 160 hp., or about 100 kw. The cost per kilowatt of rated capacity is therefore $178.13, including the building and $147.79 without the building.

The detailed cost of the steam plant was:

Building	$22,001.15	
Boilers, accessories, economizer, stack and flues (stack cost $2,800)	13,653.35	
Main engines	7,210.31	
Electric generators	3,969.90	
Switchboard and auxiliary electric equipment	2,185.48	
Miscellaneous plant equipment	199.71	
General equipment (not specified in the company's accounts)	823.45	
Engineering and superintendance	2,334.97	$2,378.32

The rated capacity of this plant is 250 kw. The cost per kilowatt, including the building is therefore $209.51, and $121.50 per kw., not including the building. A comparison of first costs may be made more readily if the figures are arranged as follows:

	Including Building	Not including Building
Cost of gas plant per kilowatt	$178.13	$147.79
Cost of steam plant, per kilowatt	209.51	121.50

The superior character and high cost of the building housing the steam plant constitutes an excessive burden on the operating charges, even though the rate of depreciation charged is only 2 per cent. A building cost of nearly 50 per cent. of the total plant cost seems to the author to be unwarranted, especially as the cost of building materials and labor were not above the average.

The cost figures for the years 1909, 1910 and 1911 were accurately kept up to the time of starting the steam station, which was about the first of October, 1911. The principal items making up the total costs are as follows:

	1909	1910	1911 (Jan. —Oct.)
Station labor	$2,234.18	2,892.88	2,499.94
Fuel	1,097.67	1,611.75	1,356.15
Supplies and expenses	219.91	353.16	299.81
Repairs	587.40	940.30	183.51
Total	4,139.16	$5,798.09	$4,339.41

A distribution of the repair account should be instructive and is as follows:

	1909	1910	1911 (Jan.— Oct.)
Building	$ 31.06	$128.33	$46.53
Gas power equipment	512.66	561.31	136.98
Electric equipment	22.86	147.97	.....
Water supply		20.68	.....
Miscellaneous	20.82	82.01	.....
Total	$587.40	$940.30	$183.51

It is possible that one reason for changing to steam power is shown in the cost of repairs to the gas-power equipment.

The amount of power developed in the gas-power station was ascertained from the daily log in which the power was entered for each half hour of the day. No recording wattmeter was used in this station. During the year 1910, the total load for the year amounted to 176,660 kw.-hr. The daily load was distributed approximately as follows: An average of 11 kw. for a period of 10 hr., an average of 15.2 kw. for 10 hr., and an average of 55 kw. for 4 hr., with a maximum of about 75 kw. for about 1 hr. The loading factor was very small, slightly over 20 per cent.

The cost per kilowatt-hour, not including fixed charges, for the year 1910 was \$5798.09 ÷ 176,660 = 3.28c. Of the items constituting the operating expense, station labor constitutes 50 per cent., fuel 28 per cent., supplies, 6 per cent., and repairs about 16 per cent. of the total. The repairs to the gas machinery during this period amount to nearly 4.9 per cent. of the first cost.

The fixed charges are calculated on the following assumed percentages of the first cost: Depreciation on building, 2 per cent., on all machinery in the building, 5 per cent.; interest on investment, 5 per cent.; taxes and insurance, 3 per cent. On these percentages the yearly amounts are:

Depreciation, building	\$ 60.66
Depreciation, machinery	738.97
Interest on investment	890.63
Taxes and insurance	534.37
Total	\$2,224.63

Total Operating Cost of Gas Plant

The total operating cost of the gas plant for the year 1910 is the sum of \$5798.09 and \$2224.63, or \$8,022.72. The total cost per kilowatt-hour is therefore nearly 4.54c.

For the year ending Dec. 31, 1912, the cost of operating the steam plant was as follows:

Station superintendance and labor	\$3,614.64
Fuel	4,126.95
Supplies and expense	570.87
Repairs of building	114.02
Repairs of steam equipment	54.20
Repairs of electric equipment	43.84
Repairs, miscellaneous	21.57
Total	\$8,546.10

These itemized expenses are very nearly the following percentages of the total expense: Superintendence and labor, 42 per cent.; fuel, 48 per cent.; supplies and expenses, 6.7 per cent.; repairs to building, 1.3 per cent.; repairs to steam equipment, 0.63 per cent.; repairs to electric equipment, 0.51 per cent., and miscellaneous repairs, 0.36 per cent.

The amount of power developed in the steam plant during the year 1912, as measured by the recording wattmeter, was 263,150 kw.-hr. The load factor for the entire year was higher than that of the gas plant, being nearly 29 per cent. The maximum load came in November and December and was about 115 kw.

The operating cost per kilowatt of power developed was therefore 8546.10 ÷ 263,150 = 3.25c. per kw.-hr.

The fixed charges against the steam plant are calculated on the same percentages as those on the gas plant, except for a known charge for boiler insurance which does not affect the propriety of the percentages for taxes and insurance. The amounts of the fixed charges for the steam station therefore become as follows:

Depreciation, building	\$ 440.02
Depreciation, machinery	1,518.85
Interest on investment	2,618.91
Taxes and insurance	1,571.35
Total	\$6,149.13

Total Operating Cost of Steam Plant

The total operating cost for the steam plant for the year 1912 is therefore the sum of \$8546.10 and \$6149.13, or \$14,695.23. This sum divided by the load in kilowatt-hours (263,150) gives a total cost per kilowatt-hour generated of very nearly 5.6c. Of the total cost of operation, the fixed charges amount to nearly 42 per cent.

In the gas plant, the fixed charges amount to only 27.7 per cent. of the total cost of generation.

It may be noted that no mention has been made of the value of the land in either case. The company owning the lighting system owns a considerable amount of land in the vicinity of the plant, and the value of that on which both the gas and steam plants are situated is so relatively small and so nearly equal in both cases that no appreciable error is made in disregarding it in the calculations.

Comparative data for the two plants will be best shown if arranged in the form of a table and this is done as follows:

	GAS	STEAM
Cost per kilowatt-hour of rated capacity, total	178.13	209.51
Cost per kilowatt-hour of rated capacity, without building	147.79	121.50
Rated capacity of station, kilowatts	100	250
Load factor for year considered	20 percent	29 percent.
Size of anthracite fuel	Pea	No.1 Buckwheat
Price per ton at the plant	3.90	3.50
Total cost of generation, cents per kilowatt-hour	4.54	5.6
Cost of generation, without fixed charges	3.28	3.25
Percentage of generating to total cost	72.3 percent.	58 percent.

It is the opinion of the author that some of the figures shown depart from what may be considered average practice, and these abnormal conditions have considerable influence on the cost of generation. The large amount of unburnt fuel and the excessive repair charges in the gas plant undoubtedly make the generation cost of 3.28c. higher than the average.

The high fixed charges against the expensive building of the steam plant makes the operating cost excessive.

The fairer basis of comparison is perhaps the cost of generation without the inclusion of fixed charges. The figures of 3.25c. for for the steam station might be considered very fair for the conditions of operation, while the figure of 3.28c. for the gas station is, in the writer's opinion, higher than could have been obtained by better operation which was easily possible.

Lignite as a Fuel for Gas Producers

By G. W. Muench

As a fuel lignite is inferior to the higher grades of coal, being less distantly removed from woody fiber, and containing more hydrogen and usually considerable water. Much of the latter, however, dries out on exposure to the air. In some cases as much as 40 or 50 per cent. of water is found in the freshly mined lignite, of which at times 20 per cent. remains when air dried. This greatly affects its value as a fuel.

The amount of ash varies greatly, in some cases being as low as 0.9 per cent. and in others as high as 58 per cent. In burning lignite under boilers there is considerable loss in the waste gases on account of the quantity of air introduced and the moisture carried off.

Although unsatisfactory under boilers, it can be handled very successfully in a gas producer. In the Pacific Northwest producers are operating on lignite having a

heat value as low as 7500 B.t.u. per lb. as fired and seldom higher than 9500 B.t.u.

All lignites contain a high percentage of volatile matter, and, therefore, a large amount of tar, which has been a hard proposition to overcome successfully, to prevent the clogging of pipes and valves and to keep it out of the engine cylinders. However, there are now many gas washers which clean the gas thoroughly. Many types of centrifugal washers have been invented, and the most successful of these wash the gas so thoroughly and allow so little tar to pass through with the gas that an extremely small quantity reaches the engine cylinders. To be fit for use in an engine the gas should not contain more than 0.0205 gr. per cu.ft. This degree of purity is obtained without much trouble, providing the producer is properly handled. Regardless of the type of power plant, one must always count on reliable engineers and firemen.

Some lignites cause trouble on account of clinkers. However, skillful handling of the fire and the proper amount of steam will overcome this trouble with the average lignite. It is practically impossible to tell from the proximate analysis whether or not a coal clinkers. In the writer's experience the best way to test a coal for clinkering properties is as follows: Take a piece of 8- or 10-in. pipe about 2 or 3 ft. long; place this over a forge blast, fill it with the coal to be tested; turn on the blast slowly and allow it to burn, and keep conditions as near as possible to the working conditions of a producer. If the fuel has a tendency to clinker badly the whole mass will form solid in the pipe. This method is rather crude, but nevertheless gives a fair idea of what may be expected when used in a producer.

The writer has not only analyzed in the laboratory a great many samples of lignite, but has also tried out many in producers in actual operation and obtained analyses of the resulting gases. The following analyses were not made with special reference to the quality of the lignites for various purposes, but only as to whether they could be used in a producer satisfactorily. In all cases the plant was operated by the regular crew and under normal operating conditions. The 300-hp. suction producer of the up-draft type furnished gas for a 250-hp. Muenzel gas engine. The washing apparatus consisted of a tower scrubber, dry scrubber and centrifugal tar extractor. The engine load consisted of a refrigerating machine and a generator, and was rather variable. Table 1 gives the analyses of lignites actually used.

TABLE 1

	1	2	3	4	5	6	7	8
Moisture	19.0	17.8	11.6	9.7	22.0	7.7	8.2	20.8
Volatile matter	31.3	29.7	37.5	24.9	24.8	53.5	44.6	32.8
Fixed carbon	35.8	32.0	36.6	36.2	27.8	20.5	30.0	32.1
Sulphur	1.7	1.8	0.6	0.4	0.5	0.4	0.4	1.4
Ash	12.2	18.7	13.7	18.8	24.9	17.9	16.8	12.9
B.t.u. per lb.	10,300	9943	10,925	10,598	8400	8269	10,488	10,177

Remarks: Samples Nos. 1, 2, 5 and 8 were non-coking; No. 4 slightly coking and Nos. 3 and 7 clinkering.

All coal analyses for heat value were made with a Parr calorimeter, and in all cases four or five samples were analyzed completely and the figures shown are average values. The heat value in all cases is that of the dry coal. All the samples were taken directly from the car and the regular quartering method was used for obtaining a good average sample. All samples were kept in air-tight jars and in most cases the analysis was made the same day the sample was taken.

Table 2 gives the analyses of the gas produced by these lignites. The samples were drawn from the suction line between the dry scrubber and the engine and all analyses were made with a Hempel apparatus. A number of analyses of each sample were made in all cases, and a number of samples were taken at various times; the figures in the table are average values.

TABLE 2

	1	2	3	4	5	6	7	8
Carbon-dioxide	6.8	6.0	7.5	8.9	5.4	4.0	7.0	7.6
Oxygen	2.6	2.2	1.9	2.3	2.6	0.8	3.0	0.4
Hydro-carbons	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.0
Carbon-monoxide	14.2	12.9	11.6	10.8	14.6	15.8	8.8	14.6
Methane	6.3	6.8	7.0	6.2	8.5	12.7	7.3	6.1
Hydrogen	12.2	8.7	8.6	12.5	13.3	8.0	8.0	10.6
Nitrogen	57.9	63.4	63.1	59.3	55.6	58.7	65.8	60.7
Heat value per cu.ft. B.t.u.	171	150	162	141	182	208	118	152

Samples Nos. 1 and 2 contained a very slight trace of hydrogen-sulphide (H_2S). Sample No. 3 was taken while the producer was clinkering badly. Gas No. 5 contained 0.00528 gr. of tar and dust per cu.ft., and gas No. 6, 0.00385 gr., both of which were well within the safe limit. Other tests for purity were taken occasionally and although some were higher than these figures, none were higher than 0.015 gr. per cu.ft. Such a degree of purity, of course, calls for very efficient gas-washing apparatus and plenty of water. These samples of lignite varied in volatile matter from 24.8 per cent. to 53.5 per cent. This large amount of tar does not mean that it is an absolute loss where no byproduct apparatus is used, for even the raw, tarry matter, if passed through a skimming tank, can be sold without any expense in handling and without any added trouble.

Besides the lignites given in Table 1, samples of other low-grade coals were obtained from various mines. Analyses of these are given in Table 3.

TABLE 3

	9	10	11	12	13
Moisture	5.3	1.8	21.4	5.6	11.2
Volatile matter	44.4	41.3	20.5	44.7	45.7
Fixed carbon	46.9	44.2	14.3	29.7	27.3
Sulphur	0.4	3.2	3.8	0.8	2.0
Ash	3.0	9.5	40.0	19.2	8.2
B.t.u. per lb.	13,013	13,107	6,100	9,928	10,500
Remarks	Coking	Coking			

	14	15	16	17	18
Moisture	24.4	1.2	21.0	23.5	4.7
Volatile matter	35.1	23.1	36.6	32.6	29.6
Fixed carbon	30.3	66.0	34.1	31.7	53.5
Sulphur	2.0	0.7	1.7	1.0	3.1
Ash	8.2	9.0	6.6	11.2	9.1
B.t.u. per lb.	10,500	13,138	10,850	10,850	12,680

Table 3 shows coal varying in moisture from 1.2 to 24.4 per cent. and having ash as high as 40 per cent. with a heat value as low as 6100 B.t.u. per lb. of dry coal.

Of course, there are many coals in the same section of country that are of a very much better grade than those given, but the idea is to show that enormous quantities of extremely low-grade coal exist, nearly all of which are good for gas-producer use.

❋

Pennsylvania Coal Production in 1912—The combined production of anthracite and bituminous coal in Pennsylvania amounted in 1912 to 246,227,086 short tons, valued at $346,993,123, against 235,218,230 tons, valued at $321,537,250, in 1911, according to E. W. Parker, of the United States Geological Survey, who compiled the figures in coöperation with the State Topographic and Geologic Survey Commission. The increase in quantity was 4.7 per cent. and the gain in value 7.9 per cent. The production of bituminous coal in 1912 exceeded that of anthracite by 77,593,890 short tons, or 93 per cent., but the value of the latter exceeded that of the former by $8,252,129.

HEATING AND VENTILATION

Time Required to Start Heating Apparatus*

In figuring the time that is required to warm up or start heating apparatus a proper allowance must first be made for the starting of the fire, or bringing it, if banked, to its normal operating condition. If the water in the boiler is cold, allowance should also be made for the warming of the water and iron in the boiler itself. As boilers are generally covered with a heat-insulating covering, the loss in heat from the outer surface of the boiler is usually small and does not, as a rule, need to be considered separately. If, however, the boiler is not covered with an insulating covering the loss in heat may ordinarily be charged directly against the heat-producing capacity of the boiler.

The question of the heat-producing capacity of the boiler is one which may be figured or which may often more satisfactorily be obtained from the boiler performance curves of the manufacturer. These curves show the steam-producing capacity of the boiler under different conditions of operation, and they are now being furnished by enterprising boiler manufacturers.

From the boiler-performance curves one can determine the steam or B.t.u. which the boiler can properly produce in a given time, say one hour or one minute. The weight of the iron and water in the boiler can also be obtained from the manufacturer or by measurement.

In the case of a cast-iron boiler the weight of the iron in pounds should be multiplied by 0.13, the specific heat of cast iron. The product will be the weight of water to which the iron is equivalent in heat-absorbing capacity. This amount should be added to the weight of water in the boiler and this sum multiplied by the difference in temperature, Fahrenheit, through which the iron and water in the boiler are to be raised. The product will, of course, represent the B.t.u. which must be given to the iron and water before steam is produced. If, therefore, the average heat-producing capacity of the boiler in B.t.u. per unit of time can be determined, the total B.t.u. required to heat the iron and water in the boiler can be divided by the B.t.u. which the boiler will produce in a unit of time and the number of units of time, whether they are minutes or hours, be determined.

After the time required to heat the boiler has been figured the time required to heat the piping and radiation in the heating apparatus itself may be determined. This is a different question from the former and the author, by means of some interesting mathematics, developed a formula for steam-heating apparatus. To illustrate the use of the equation certain examples and curves were worked out and a similar equation for hot-water heating was discussed.

In Fig. 1 each curve represents a condition in which there are certain fixed temperatures in the building at the start and also when the apparatus is completely warmed up. For example, one curve is marked 50-70 deg., F. This means that the building is at a temperature of 50 deg., F., when steam starts to enter the apparatus and that the building is at a temperature of 70 deg., F., when the apparatus is completely warmed. The curves are worked out for a steam temperature of 220 deg., F., and on the basis that each square foot of radiation calls for 7 lb. of cast-iron and gives off 250 B.t.u.

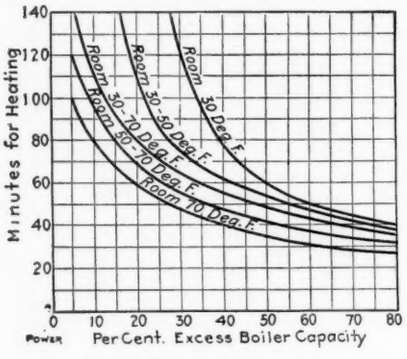


FIG. 1. TIME REQUIRED TO HEAT STEAM RADIATION

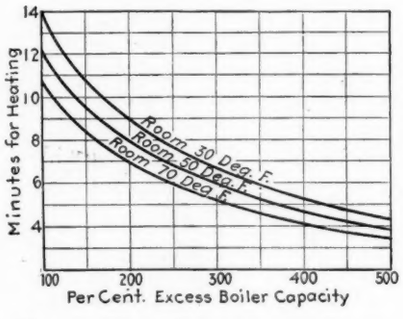


FIG. 2. TIME REQUIRED TO HEAT COVERED STEAM PIPING

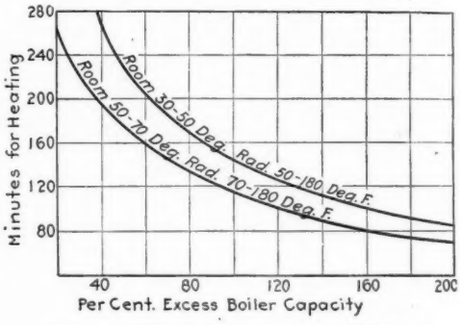


FIG. 3. TIME REQUIRED TO HEAT HOT-WATER RADIATION

(For pipe surface use from ⅝ to ¾ of time shown)

In Fig. 2 curves are shown which are similar to those in Fig. 1, except that they are figured for covered piping where the heat loss per square foot of piping is taken as 50 B.t.u. If the piping is covered the time of the heating of the covered pipes can first be determined from the curves in Fig. 2, and it can usually be figured that the total boiler supply is first used in heating the covered pipes. When this is done the heat given off by the covered pipes can be subtracted from the boiler supply and the difference can be used as the steam supply to the uncovered radiation. The time of heating the radiation itself can then be determined from the curves in Fig. 1 and added to the time required for heating the covered piping.

*Abstract of a paper read by Ralph C. Taggart before the American Society of Heating and Ventilating Engineers, July 17-19, Buffalo, N. Y.

In hot-water heating apparatus the heating of the iron and also the water in the boiler should be allowed for. The loss by radiation may then be considered proportional to the amount of heat in the apparatus, if there is at the start some little difference in temperature between the room and the water in the apparatus. If this is not so, the work may be divided into several calculations, the periods being so chosen that during each of them the loss of heat will be approximately proportional to the heating of the apparatus. This means that it will usually be sufficient to divide the calculations into two, or at most three periods, because, although there will be some variation when the difference in temperature between the heating apparatus and the room is small, still, in this case, the heat loss itself is also relatively small, so that the error is proportionately decreased.

The curves in Fig. 3 are similar to those in Fig. 1. They are based on 5 lb. of water per square foot of radiation. It is interesting to notice that, if more radiation is installed and operated at a lower temperature, the same time is required to bring either quantity of hot-water radiation up to a temperature.

The time shown by the curves of Fig. 3 might have to be increased if the pipes are large and so hold much more water per square foot of surface than does ordinary radiation. One and a half or two-inch pipe holds about the same amount of water per square foot of surface as does ordinary radiation. Doubling the diameter of the pipe doubles its surface, but its content is increased four times, so that the water in the pipe per square foot of surface is doubled. The time, however, might only have to be increased, say 50 per cent., because the iron in the piping and the iron and water in the boiler are not increased in this ratio per square foot of surface by the increase in the diameter of the pipe.

❋

Special Venturi Style Elbows*

Besides the tests described in the Aug. 26 issue of POWER, a series of tests on air ducts was also made to determine the effect of reducing the area of an elbow at the throat to the theoretical or equivalent area. The shape assumed by such an elbow is shown in Fig. 1. This special form of elbow was suggested by Konrad Meier, in his book, "Mechanics of Heating and Ventilating," and the idea advanced that by reducing the area to the equivalent orifice, eddy-currents would be prevented along the inner side of the pipe. This would tend to prevent one source of friction, and the long-cone effect would aid in changing the accelerated-velocity pressure at the turn of the elbow back to static pressure with a minimum loss.

Of the total loss of head in rounding an elbow, about 44 per cent. is regained in the straight part of the elbow after making the turn, and the balance, or 56 per cent., is entirely lost. The loss in pressure due to any elbow, as shown by the diagrams presented in the previous article divided by 0.56 gives the total loss at a point just after rounding the turn, or at the point where the theoretical orifice or blast area is to be calculated. By adding 1.0 to this total loss and taking the square root of the reciprocal, the theoretical area as a percentage of the actual area is found.

As an example of this calculation, assume an elbow in a 12x12-in. duct, the elbow to have a center-line radius of ½ *W*. According to Fig. 4, in the first article, the loss in this elbow will be 0.95 of a velocity head, and the loss at the point of equivalent orifice will be

$$0.95 \div 0.56 = 1.6 \textit{ velocity}$$

Then the blast area will be

$$\sqrt{\frac{1}{1.6 + 1.0}} = 0.62 \textit{ of the present area}$$

The foregoing represents an extreme case, and it seems safe to assume that for ordinary square-turn elbows the theoretical area is two-thirds of the actual area. That

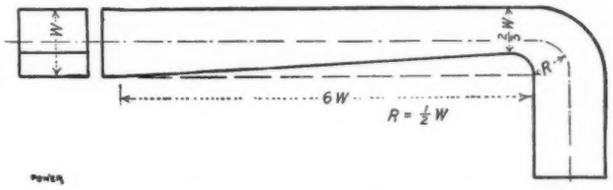


FIG. 1. SPECIAL VENTURI-STYLE ELBOW USED IN TESTS

is, with a 12x12-in. elbow the width to two-thirds of the normal size without interfering with the air flow or causing an increase in velocity due to the restriction. The greater the center-line radius of the elbow considered, the less will be the loss of pressure through the elbow and the more nearly the theoretical area will approach to the actual. Thus with an elbow having a center-line radius of 1½ *D* the theoretical area would be 94 per cent. of the actual.

To study the effect of reducing the throat of an elbow as just described, special venturi-shaped elbows were designed on the foregoing basis, and their effect ascertained in the same manner as had been already done in the case of ordinary elbows. The results of these tests are here given, and the accompanying sketches will aid in understanding the arrangements of elbows used.

Case I—A standard elbow having $R = \frac{1}{2} W$ was attached to the outlet of the test box and a 6-ft. length of pipe added to give the same length as used in making the special elbow. As indicated on the sketch, the loss due to the elbow and 6 ft. of pipe was 94 per cent. of the velocity head.

Case II—The standard elbow was replaced by the special venturi-shaped elbow, and the same conditions as to air pressure maintained. The loss now was 37 per cent. of the velocity head, showing a saving of 57 per cent. of a velocity head, or 60.7 per cent. of the loss indicated for the standard elbow.

Case III—An offset of 1¼ times the width of the pipe was arranged and two short-bend standard elbows used. The total loss from *A* to *D* was found to be 219 per cent. of the velocity head.

Case IV—The second elbow was replaced at *B* with the special elbow and the loss found to be 98 per cent. of a velocity head. The saving due to the use of the special elbow is seen to be 121 per cent. of a velocity head, or 55.4 per cent. of the original loss.

Case V—An offset of four times the pipe width was arranged with the two short-bend standard elbows, and the loss from *A* to *C* found to be 161.5 per cent. of a velocity head. The saving over Case III due to the greater offset was 21.6 per cent., but the arrangement

*From a paper read by Frank L. Busey before the American Society of Heating and Ventilating Engineers, July 17-19, Buffalo, N. Y.

shown in Case IV, where one special elbow was used, showed a saving over Case V of 44 per cent.

Case VI—Two easy, long-radius elbows were arranged as shown, to determine the saving due to these elbows as compared with the ones used in Case V. This arrangement gave a saving of 79.2 per cent. of the loss indicated for Case V.

Case VII—The same elbows were used as in Case VI, and a short length of pipe inserted between the elbows, increasing the offset from 2½ to 5½ times the pipe width. For some unaccountable reason the loss indicated was greater than for Case VI. It is possible that this arrangement is more productive of eddy currents in the

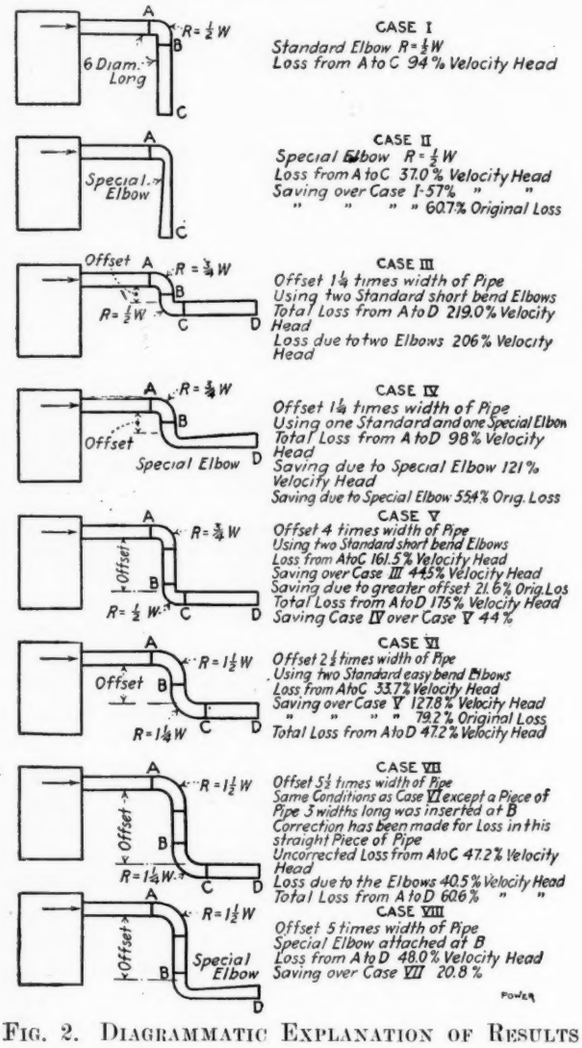

CASE I
Standard Elbow R = ½ W
Loss from A to C 94% Velocity Head
6 Diam. Long
CASE II
Special Elbow R = ½ W
Loss from A to C 37.0% Velocity Head
Saving over Case I 57% " "
" " " 60.7% Original Loss
Special Elbow
CASE III
Offset 1¼ times width of Pipe
Using two Standard short bend Elbows
Total Loss from A to D 219.0% Velocity Head
Loss due to two Elbows 206% Velocity Head
Offset
CASE IV
Offset 1¼ times width of Pipe
Using one Standard and one Special Elbow
Total Loss from A to D 98% Velocity Head
Saving due to Special Elbow 121% Velocity Head
Saving due to Special Elbow 55.4% Orig. Loss
Special Elbow
CASE V
Offset 4 times width of Pipe
Using two Standard short bend Elbows
Loss from A to C 161.5% Velocity Head
Saving over Case III 44.5% Velocity Head
Saving due to greater offset 21.6% Orig. Los
Total Loss from A to D 175% Velocity Head
Saving Case IV over Case V 44%
CASE VI
Offset 2½ times width of Pipe
Using two Standard easy bend Elbows
Loss from A to C 33.7% Velocity Head
Saving over Case V 127.8% Velocity Head
" " " " 79.2% Original Loss
Total Loss from A to D 47.2% Velocity Head
CASE VII
Offset 5½ times width of Pipe
Same Conditions as Case VI except a Piece of Pipe 3 widths long was inserted at B
Correction has been made for Loss in this straight Piece of Pipe
Uncorrected Loss from A to C 47.2% Velocity Head
Loss due to the Elbows 40.5% Velocity Head
Total Loss from A to D 60.6% " "
CASE VIII
Offset 5 times width of Pipe
Special Elbow attached at B
Loss from A to D 48.0% Velocity Head
Saving over Case VII 20.8%
POWER

FIG. 2. DIAGRAMMATIC EXPLANATION OF RESULTS

second elbow than the arrangement of Case VI.

Case VIII—The same arrangement as used in Case VII, except the second elbow was replaced with the special elbow. As indicated, a saving of 20.7 per cent. over Case VII was obtained.

As may be noted from the data given, the principal gain due to the special elbow is when it is used to replace a short-bend standard elbow in which the loss of pressure is excessive. Special elbows were also tried with a center-line radius of 1½ *W*, but, as might be expected, the gain was not sufficiently great to warrant the extra expense of construction.

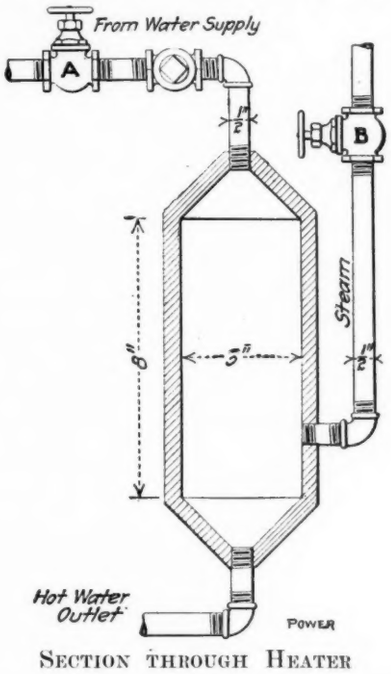
The special elbow might be used to advantage in either of two cases. First, where a horizontal run enters a riser at such close quarters that an easy elbow is out of the question and a sharp-bend elbow with center-line radius of ½ *W* must be used. Second, where a close offset must be made, as might be required in passing around an obstruction or through a wall. If the offset is sufficiently great to permit the use of long-radius, easy-bend elbows it is questionable whether it would be worth while to use the special elbow. The loss due to the easy standard elbows would be so slight that the saving due to the special elbow would be insignificant.

According to the test results the saving due to the use of the special elbow, as in Case II, resulted in a saving of 0.57 of a velocity head as compared with a short-bend elbow. When used to replace the second elbow in an offset, as shown in Case IV, the saving was 1.21 of a velocity head. In either event the saving was from 55 to 60 per cent. of the original loss.

❋

A Heater Trouble

I have the care of an Economy hot-water heater that was installed about three years ago. This heater consists of a cast-iron body 8 in. long and 3 in. in diameter with a ½-in. water inlet at the top, a hot-water outlet at the bottom and a ½-in. steam inlet on the side. To operate the heater, open valve *A* and then valve *B*. The two valves are adjusted to get the temperature desired. In the water supply there is a check valve to prevent an unequal steam pressure from forcing the water back into the supply pipe. There should also be one in the steam-supply pipe to prevent the water getting into it.



SECTION THROUGH HEATER

This heater is used when only a small amount of water is desired at one time. It heats the water all right, but it has a fault that I would like to remedy. The steam in coming in direct contact with the water causes a slight water-hammer which stirs up the sediment that has settled in the pipes and heater and causes the water to be slightly colored. If any reader has had experience with this type of heater, I should be glad to learn of a remedy for the trouble without renewing the piping.

L. N. WEBSTER.

Springfield, Mass.

EDITORIALS

Central Power Station Rates

In response to a request from the Uniform Electric-Rate Association, Louis D. Brandeis has delivered an opinion that:

Assuming that the cost of producing and delivering electrical energy is the same per unit, regardless of the quantity supplied, and in the absence of any statute regulating or limiting the price at which it may be sold, a public-service corporation cannot legally charge a lower rate for a larger than for a smaller quantity delivered at the same time and under similar conditions.

Assuming that there is a difference between the cost of making, delivering and selling electrical energy as between the wholesale and the retail consumer, a public-service corporation can, in the absence of any statute regulating or limiting the price at which it shall be sold, make a higher price to the retail customer, but the difference in selling price may not be substantially greater than the difference in cost.

Upon the case which to the lay mind would seem to offer no possible excuse for difference in rate, namely, the use to which the current is to be put, Mr. Brandeis says there is more doubt. It costs an electric company a certain (or uncertain) amount to produce current, upon which cost it is entitled to make a fair profit, and it is hard to see what difference it makes whether the customer uses the current for light or heat or power or metallurgical purposes, or electroplating or whatever else he chooses. If his work requires more of it than would some other use, it is the question of quantity, disposed of in the above-quoted opinions. If it is because the current for the specified purposes is required at off-peak times, when the plant would be otherwise underloaded, it is a question not of use or purpose but of time of service. Under no circumstances could the mere use or purpose for which the current is bought appear to justify a difference in rate or to be of any concern to the selling company.

Mr. Brandeis says that "some decisions in the state courts would seem to justify such discrimination, but the great weight of authority as well as of reason seems opposed to permitting any discrimination based upon the use to which electric energy is put; and therefore, upon the facts assumed in the question, such discrimination between charges for electrical energy used for power and charges for the electrical energy used for light should be held illegal."

"On the other hand, the difference between day use—when the demand upon the station is small—and evening use—when the demand upon the station is large—seems a proper basis of classification of service; and a court might, for this reason, upon the facts disclosed in a particular case, hold that use for power as calling mainly for day use, fell within a different class of service than use for light."

Here again it is admittedly a question of time and not of purpose, and the confining the use to power purposes does not necessarily keep the demand off the peak, although it extends the demand over the period of light load and increases the power factor.

A plant designed primarily for furnishing electric light, having only a night load and selling current at a price which pays a profit upon the total cost of production, including all the standing charges, could afford to sell current at a very low price during the day time. The extra cost of producing that current would be very small and it could be sold at a price with which the isolated plant could not compete unless it had use for a large proportion of its exhaust steam. The result would be that the day user would get his current cheaper than he could make it, the electric company would make money, and the night user would pay no more, although he would not share in the improved efficiency of larger use of the plant.

In making up the "difference in cost" of different services upon which a difference in rates may be allowable in the second opinion above quoted, is the day or power load to be allowed to escape all overhead charges, or all except those which are directly occasioned by its taking on, or is it to be made to bear its proportion of the whole of them?

What would be the case if the power or day load were the principal part of the business, if a plant were put down primarily to run a group of mills and factories. Would they charge all the overhead expenses in making up the cost which should establish the day rate and then sell the current for lighting at night at a fair profit on its *additional* cost?

If the standing charges are to be equally distributed over the production, i.e., the charge per unit determined by dividing the total standing charge by the number of units produced, the average cost will be above that at which current can be sold in competition with an isolated plant of any considerable size. And this leads to a most pertinent and important point in the opinion, not brought out in answer to any direct inquiry, but coming in incidentally, and that is to the effect that a public-service corporation cannot discriminate in rates, because it cannot get the business otherwise; that it is not justified in cutting rates to meet competition unless it cuts them to everybody.

We shall be interested to see what view the courts take of the question, if, as we understand it, the intention of the association is to bring some test cases to trial.

⁂

Appreciation of the Engineer

More and more as men are graduated from engineering schools, the profession of engineering, in its various divisions, is coming to rank with law, medicine and the other professions, both as to dignity of occupation and enjoyment of protection. The time has passed when buying a transit makes the purchaser a civil engineer,

or stringing a wire to light his kitchen makes a man an electrical engineer.

So much for the technical fellows, and we hear the vast number of good, practical men call "More power to their arms." Each year shows closer coöperation between the young fellow with his degree and the man with his years of practical experience. The old feeling of animosity is being replaced by a spirit of exchange of knowledge which works for the betterment of both men.

Today, we find in the larger plants a man who is known as the chief engineer. In his department and under his direction are to be found assistant engineers, oilers, firemen, etc. Here the engineer is looked upon by the management as a man who shoulders a vast amount of responsibility and upon whose efficiency depends the plant production, to a large degree. Other plants, although smaller, are fully as important when proportion of operating expense to output is considered. Here we probably find one man acting as chief engineer, assistant engineer, oiler and fireman, but the consideration he receives seems to be inversely proportional to the diversity of his duties.

Not infrequently a department foreman not only enjoys closer coöperation with the management, but is rewarded more generously for his services, than is the man at the head of the power department.

Consider a few of the responsibilities of both positions. The foreman must look to the welfare of the employees working in his department. In case of accident, he signals to have the machines stopped, and production in his division is retarded for a short time. The engineer is responsible for the life of every person in his building, and, in closely settled districts, the people in the adjoining buildings. The engineer must not have accidents—it is part of his duty to see that they do not happen.

How much intelligence a foreman must have to hold his position, is indefinite, but a glance at the requirements for an engineer's license is convincing that the framed document in the engine room stands for head work as well as hand work.

There is one man, however, who defers to the engineer—the purchasing agent. He may be able to select the department material as well as the foreman, but when the article happens to be a sample of packing, a new type of blowoff valve, a solution of the boiler-scale problem, etc., the representative is generally told to "just step back to the rear and talk to the engineer; he is the man who knows about these things."

Much is being accomplished by the splendid organizations of engineers which are to be found in most towns and cities. For one thing, they place a limit to the time that the engineer may be away from his engine room. This alone has done away with such unpleasantnesses as the following:

A first-class engineer in a plant, who also acted as fireman, millwright, master-mechanic and general trouble-man, was found by his employer reading his technical paper. The employer hurried out of the engine room, but returned in a few moments and ordered the engineer to lay down his paper, and come with him to the lawn in front of the office, where he could spend his time to better advantage in digging the weeds out of the grass. This employer was surprised to learn that his engineer was limited to 15 minutes absence from his engine room.

Such employers fortunately are of the old school and fast disappearing. The new generation in control is largely made up of graduates of technical schools, and these men realize and foster a closer bond between themselves and their engineer. Each year shows more attention being given to the vital point of the plant—the power house, and with this is to be expected an increased consideration, on the part of the management, for the engineer.

Plant Repairs during the Slack Season

In the late summer many industries have their slack season, and frequently the plant is shut down for a week or so. At these times the engineer has a chance to do considerable repair work. Perhaps no time would be better to make readjustments of operating conditions, not only in the power plant, but through the various departments that go to make for the finished output. Possibly the engineer has felt for the past six months that the friction load was excessive. A careful inspection of shafting, noting alignment, condition of bearings, hangers, etc., may often make a considerable reduction in the friction load.

There is always the repacking and truing up of the various units, and the piping will need some attention, but while working with the piping it may be possible to make some changes, which together with the proper pipe covering, will show a saving for the boiler feedwater heater or the exhaust-steam heating system. If an air compressor be among the equipment it may be possible to reduce the leakage.

When the main unit drives a generator, it is well to have the switchboard instruments corrected. This may mean either sending the instruments back to the makers, or if time will not permit of this, it would be well to have comparisons made with standard instruments.

Throughout the plant where motors are used it may be possible to improve conditions of load. By placing the motor nearer the center of load, that is, having the load more evenly distributed along the line shaft, to both sides of the motor, an improvement may be effected.

Many modern machines are supposed to be operated at high speeds. With proper selection of speed of motor, size of motor pulley and line-shaft pulley, the correct operating speeds for the machines can be attained. This will prove to be a more efficient condition for the machine, and with more nearly rated loading of the motor, a more efficient motor operation will also result. A saving of power will follow, which is the engineer's aim.

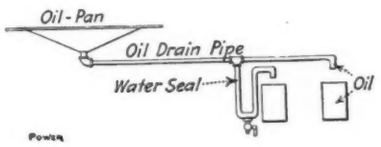
Other things could be mentioned, but the important point is that just at present, when so much is being said about efficiency engineering, the wide-awake engineer is eager to make any reasonable change in his equipment or load conditions that will result in a saving in power costs. It often happens that it is hard for an engineer to get the concern to purchase much new equipment for the power plant, not realizing that such expenditures are investments. For this reason it is necessary for many engineers to make the best possible use of the equipment at hand. Hence, the slack season of summer may be the busy one for the engineer with pet schemes to work out.

READERS WITH SOMETHING TO SAY

Three Useful Kinks

In many plants the installation of economy devices is not always justifiable. For instance, in the plant where the writer is employed there are two self-oiling engines and one which is oiled by hand. An oiling system might be employed on the one unit, but as it operates only six hours each day it is a question whether it would pay for itself by the time it had depreciated beyond usefulness.

The crank of the engine in question is oiled from a reservoir of about one gallon capacity, which is attached to the frame in such a manner that the oil can flow to the crank bearing by gravity. After leaving the bearing the oil falls to the oil-pan in the lower part of the engine frame and from there is drawn into a suitable vessel and again returned to the reservoir to be used over again. The engine being vertical, considerable water leaks into the oil-pan and mixes with the oil. This water



OIL-WATER SEPARATOR

must be separated from the oil before it can be returned to the reservoir for use. This used to be done by drawing the water from the bottom of the oil reservoir, but no matter how carefully this was attended to some water always found its way to the crank bearing, which did the latter more harm than good, necessitating frequent adjustment. I hit upon the scheme shown in the sketch, which is self-explanatory. Since the application of this simple device the crank-bearing has been running without adjustment, and the prospect is that it will do so for some time to come. The material used is of small consequence and the relief from worry and saving of wear fully justifies the time and material put into the job.

On the same engine there is a Rites governor. The eccentric is on one side of the flywheel and the weight-arm on the other. The eccentric-pin bearing had a tendency to wear oblong near the weight-arm due to the alternate direction of the force required to move the valve. This action was further aggravated by a slight wobbling of the flywheel. To overcome this trouble one end of a spring was attached to the center of the governor pin and the other end to the rim of the flywheel in such a position that it counteracted the to and fro movement of the governor-pin in its bearing and held it in line. A little experimenting had to be done before the correct position of the spring and the proper tension was found. The regulation is now entirely satisfactory. The spring used was an old automobile spring and did not cost anything, but its application saved the cost of fitting new bearings and the regulation is better than ever before.

Sometimes a lubricator feed-glass is encountered which gives a good deal of trouble by becoming dirty, thus causing the oil to flow along the side of the glass in a stream instead of rising in drops. It was found that a fine wire placed in a vertical position exactly in the center of the feed-glass would overcome the trouble and also prevent the bursting of the feed-glass from unequal expansion. The method of fastening the wire is immaterial as long as the flow of the oil is not obstructed. The writer uses a piece of 50- or 75-amp. fuse bent into a circle of the same diameter as the feed-glass. To this ring the fine wire is attached so that it is exactly central at right angles to the diameter of the ring. The wire is then cut to a length which will permit the end to enter the feed nozzle from $\frac{1}{16}$ to $\frac{1}{8}$ in., when the ring rests upon the upper end of the feed-glass. This scheme may not work very well in case the lubricator is required to feed very rapidly, with a very heavy oil.

LOUIS T. WATRY.

Pueblo, Colo.

Why Did Trap Fail to Drain Dry Cans?

In our plant there are a number of dry cans on which the cloth is dried before being calendered. Up to about three months ago the condensation from these cans returned by gravity to a receiver situated about 30 ft. from the dryers and 22 in. lower. A pump, governed by a float in the receiver, pumped the water into an open heater, a rise of 28 in.

The pressure in the cans ranged from 6 to 12 lb. The heater pressure is never higher than 1 lb. and oftener it is a partial vacuum. With these conditions we saw no reason why a trap placed near the receiver and loop would not do the work of both and effect a saving. A trap salesman agreed to put a trap in with the understanding that if it did not drain the cans his company would take it out, with no charges for the installation. The trap was installed and our troubles began, but there was no fault with the trap. All the water which came to it was discharged into the heater, but for some reason, which is not clear to me, only a part of the water flowed to the trap, and the cans would not dry. We thought the pipes were air bound, and put in air-relief cocks, but the cans were continually full of water.

Our puzzle was and is, why the water should not flow as freely to a trap as to the pump receiver. We finally set the trap directly beside the cans, which then operated free of water, the trap doing its work satisfactorily. The question is, Why did it not work satisfactorily when first installed?

L. JOHNSON.

Exeter, N. H.

The Independent Plant

Many of the recently published descriptions of independent plants, as well as some of the arguments, pro and con, have been interesting. They reflect, in small measure, the widespread nature of the question. The writer has always contended that with properly adapted, first-class apparatus, almost any plant could, and many do, show superior over-all results to central-station service. In Northern cities the requirement of heating is of decided advantage, and without this credit, the case would be far more difficult.

From this it is an easy step to "block plants," supplying current and heat within their limits, and being real central plants. Moreover, the modern Corliss-valve direct-connected engine, with its flat steam-consumption line, and the natural-draft cooling tower and condenser make an ideal combination. For summer service, such a plant may run condensing, with minimum cost, and practically on an equality with the central station, so far as cost of current at the switchboard, in each case, is concerned. In winter, all the exhaust steam should be utilized, at attractive return.

Again, an existing high-speed installation, perhaps of poor efficiency, can be improved by the addition of a small low-pressure turbine, augmenting and improving the total economy to a remarkable extent. These results were not possible a few years ago, before the development of the four-valve engine, the small turbine, and correct low-cost condensing and water-cooling apparatus.

Or a heating system, either steam or water, can be so connected in between the engine and condenser as to use a large part of the heat generated by the boiler.

Take, as a case, the present high-speed Corliss-valve direct-connected engine, with an initial cost of about $40 per kw. and a steam consumption of not more than 35 lb. per kw.hr., noncondensing, and 27 lb. condensing, the total cost per kw.hr. on a yearly output of, say, 250,000 kw. hours and $4 coal, would not be much over 1¼ cents, all charges included, and no credit for heating. For five to eight months during the year 75 per cent. of the exhaust steam is absorbed by the heating requirements, which would reduce the net cost to about 1 cent, a rate which the central company, with its heavy overhead expense, could not meet, and remain in business.

Better yet, take the very flexible plan of several high-speed units exhausting to a receiver from which a mixed-pressure turbine and a heating system is fed, with connections so arranged that any combination of the units could be secured, the cost would be still further reduced, and the plant become a very profitable investment to the owners and a source of economy and satisfaction to its patrons. These turbines range about $30 per kw. for small sizes, with condensing apparatus about $7.50 per kw., and the power so developed is almost a net gain.

It is usually with old, poorly apportioned machinery, badly operated, in depreciated condition, without complete and authentic records of cost, that the central stations can make a showing on a strictly engineering basis. Granted, that if a new boiler plant is necessary, requiring expensive changes in buildings and occupying valuable space, if the engines are run down and the repair bills high, with frequent exasperating shutdowns, labor troubles, etc., there is little argument.

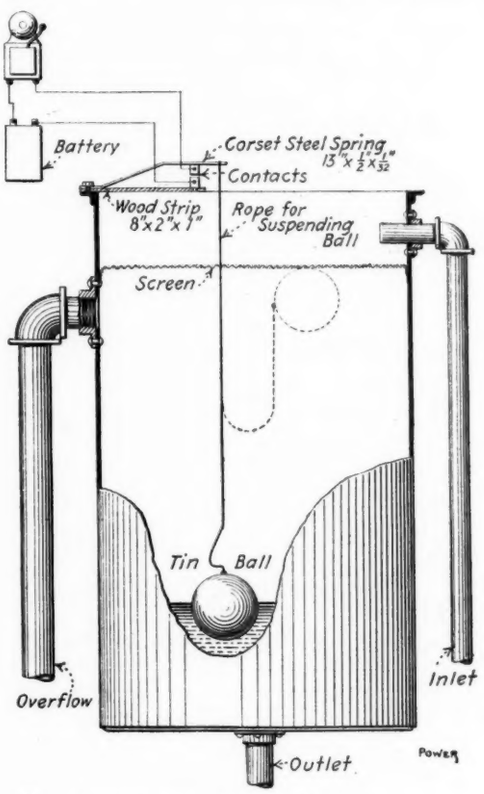
Unfortunately there are many such plants. But in comparing results from a modern well equipped central station it is manifestly unfair to take the independent plant in any but the same condition. Each case is a problem in itself, deserving of careful study by a trained, unbiased judgment, and the result is almost a certainty when so handled. The independent modern plant has nothing to fear if given fair consideration. But this implies an intelligent, well read engineer, up to date on the developments of recent years, and with accurate records of his plant condition and costs.

W. G. STARKWEATHER.

Boston, Mass.

Alarm for Oiling System

The need for an alarm device on oil-tank service is this: All practical men know that the oiler has other things to attend to beside oiling. It is generally the case that something will happen to the oiling system when he is wiping up a machine or polishing bright work. The filter tank is usually in the basement and out of sight most of the time. The gravity tank is elevated in or above the engine room, and the chances are that the oil level in the gage-glasses of this tank cannot be seen unless one gets back in some corner to look at it. The screen gets dirty and the oil will go on the floor, either at the upper tank or the lower one, and one does not know that the basement tank has overflown until it is too late to prevent damage or loss of oil.



ALARM FOR OILING SYSTEM

The supply pump will slow down and all the oil will go to the lower tank and remain there. By equipping the tanks with the device shown all such trouble may be avoided. The illustration is self-explanatory.

Dallas, Tex. JOHN BUTERA.

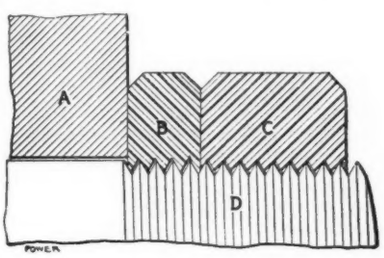
QUESTIONS BEFORE THE HOUSE

Jam Nuts

In "Inquiries of General Interest," June 24 issue, in the answer to the inquiry on "jam nuts," the answer was that the thick nut should be put on first, for, having more threads, it can be drawn up tighter with less danger of stripping the threads, and on account of its greater thickness it can be more easily held by a wrench while the outside nut is turned.

A locknut is usually about one-half as thick as the ordinary nut and for the simple reason that a wrench is generally thicker than this, the nut is placed on the outside for convenience. I am of the opinion, however, that the small nut should be placed next the piece that is being bolted.

Referring to the sectional view, we may imagine a very small clearance between the threads of a nut and the threaded part of the bolt *D*. Then a single nut, when it is tightened against the piece being bolted, will appear as *C* in the figure, the clearance between threads being on



JAM NUT PLACED INSIDE

the right-hand side in this case. In applying the locknut as at *B* it is first tightened against the piece *A* and the nut *C* is then tightened on the top of *B*. The locknut then is tightened back on *C*, the outer nut being held firmly with a wrench, this action grinding the surfaces of the two nuts together; or by holding nut *B* and tightening *C*, we have the same effect without loosening the hold of the bolt. The clearance of the small nut is on the left as indicated in the figure. It will be seen that the large nut not only resists the pull indicated by the contact, but also the load applied by the small nut when it is turned back.

To avoid mistakes a compromise may be made by having both nuts of the same thickness and equal to about three-fourths the thickness of the ordinary nut or where appearance is not a great consideration, two nuts of usual thickness can be used.

CHARLES JABLOW.

Stillwater, Okla.

[In most situations where a gain or lock nut is employed it is both necessary to obtain the maximum draft before setting the jam nut and to retain the position of the inside nut without backing it against the outside nut. The inside nut must, therefore, be the main nut and the outside nut the jam or lock nut.—ED.]

Says Graphite Is Successful

The letter by E. C. Sutton, of the Esterville (Iowa) Light and Power Co., printed in the Aug. 19 issue, under the heading "Had No Success with Graphite," was read with interest. My experience with graphite has been very different.

Some months ago my advice was solicited by the management of the Castle Heights Water Co., of North White Plains, N. Y., as to a remedy for removing and preventing scale incrustation in the boilers of this company.

I examined the boilers, which were of the horizontal tubular type, and found that there was an average scale incrustation approximating ½ in. in thickness deposited over the interior of the boiler shell and tubes. The feed water used at this plant is not unlike the water of the Croton Watershed, showing an average alkalinity of about 34 parts per million; a permanent hardness of 5 parts, making a total average hardness of about 39 parts per million.

There being two boilers at the plant of 150 rated horsepower, either of which is capable of operating the plant, it was found convenient to try a scale-removing substance upon the heavily incrusted boiler, which at the time of the test was in reserve.

I decided to try graphite on the reserve boiler, known as No. 2. On May 8, I ordered No. 2 boiler placed in operation, at the same time instructing the engineer to feed the graphite to the boiler, through a receptacle tapped and connected to the feed line, on the suction side of the feed pump, and to feed 3 lb. of graphite each day for the first three days and to blow down at the end of the third day. After the third day the quantity of graphite fed was reduced to 1 lb. per day and the boiler blown down every second day until opening up, my intention being to run the test for at least 30 days before shutting down.

On May 25, after 17 days' run, I unexpectedly was compelled to shut down for insurance inspection, and was indeed much disappointed to have to do so as I imagined the graphite did not have sufficient opportunity to demonstrate its scale-removing qualities. My disappointment was more than compensated for, to find upon examination, that the interior of the boiler and the tubes had become practically cleared of scale. Further examination through the rear handhole opening showed that quantities of the carbonates of lime and magnesia mingled with graphite had been precipitated in a sludge consistency easily removable by blowing out.

I am now running a test to determine the worth of graphite as a scale preventive and expect to have the same success, and indeed I am very optimistic of the result as the boiler continues to show increased steaming qualities with a minimum coal consumption.

DANIEL I. CURTIN.

New York City.

Pitting of Boilers Due to Furnace

Under this heading E. Herzog, of Chicago, stated in the July 15 issue, first: "The pitting of boilers in Chicago seems to be quite characteristic to boilers having the dutch-oven type of furnace." Second: "The object of installing this type of furnace is to eliminate smoke, which it does after the furnace gets hot." Third: "This action does not occur in other boilers that use distilled water, but have not that kind of a furnace."

A Chicago ordinance provides for smoke inspection and abatement in the City of Chicago. Sections 14, 15 and 16 read as follows:

Section 14: No new plants or any reconstruction of any old plants for producing power and heat, or either of them, or any new chimney connected with a steam plant shall be erected or maintained in the city until plans and specifications of the same have been filed in the office of and approved by the smoke inspector and a permit issued by him for such erection, reconstruction or maintenance. Plans and specifications to be filed with the smoke inspector shall show the amount of work and the amount of heating to be done by such plant and all appurtenances thereto, including all provisions made for the purpose of securing complete combustion of the fuel to be used and for the purpose of preventing smoke.

Section 15: It shall be unlawful for any person to use any new or reconstructed plant for the production and generation of heat and power, or either of them, until he shall have first procured a certificate from the smoke inspector that the plant is so constructed that it will do the work required and that it can be so managed that no dense smoke shall be emitted from the chimney connected with the furnace or firebox.

Section 16: No owner shall alter or repair any chimney or any old furnace or device which alteration, change or installation shall affect the method or efficiency of preventing smoke, without first submitting plans and specifications to the smoke inspector and securing a permit therefor, provided, however, that minor necessary repairs which do not increase the capacity of such plant or which do not involve any substantial alteration in structure and which do not involve any alteration in the method or efficiency of smoke prevention may be made by or under the engineer in charge of said plant without a permit. Any person who shall violate this section shall be liable to a fine of $25 for each day upon which he shall prosecute such alteration, change or installation without a permit, and each day's violation shall constitute a separate offense.

By virtue of this ordinance the Department of Smoke Inspection maintains a record of all new installations as well as all important reconstructions. The records of the department for the year 1912 show that during this year the department issued 263 permits affecting construction or reconstruction of furnaces under 485 boilers. These furnaces were divided as follows:

Hand-fired furnaces	323
Mechanical stokers	121
Gravity-feed furnaces	37
Oil-burning furnaces	4

Each group was subdivided as follows:

D. A. B. W. furnaces	206
McMillan furnaces (modified)	8
Extension hand-fired furnaces	19
Tile-roof furnaces	17
Defl. arches and semi-bit. coal	1
McGinniss arch furnaces	1
Dept. No. 4 furnaces	2
Twin fire-arch furnaces	29
Down-draft furnaces	13
Dept. No. 7 furnaces	22
Chain-grate stokers	68
Underfeed stokers	11
Taylor underfeed stokers	5
Side-feed stokers	15
Roney stokers	14
Swift stokers	6
Butman rotary-grate stokers	2
Waste heat hand-fired furnaces	4
Standard setting air ducts	1
Asphalt stills	3
Waste-heat mech. stokers	1
Burke & McKinzie furnaces	37
Total	485

From this table it can be seen that out of 485 furnaces only 19 were extension furnaces, and most of these were used to burn special fuel. In short, the dutch-oven type of furnace is not installed at present as a smoke preventer but is used to utilize fuels which can not be used in furnaces of a lower temperature, or to accommodate boilers which by the nature of their construction can not be equipped with any other type.

As to the third proposition advanced by Mr. Herzog, that is, "This action does not occur in other boilers that use distilled water, but have not that kind of a furnace." With the permission of Mr. Monnett, chief smoke inspector, Chicago, I sent a letter to various boiler-insurance companies, requesting information as to how the average condition of boilers in Chicago compared with other cities, and whether it was true that boilers in Chicago are subject to pitting more than the boilers outside of Chicago. Another question was, what percentage of boilers under observation in Chicago have this trouble to a marked degree, and how does it compare with the percentage in other cities?

In answer to this letter one company stated that its records do not show that the condition of boilers in Chicago, insofar as pitting goes, is any different than in most other sections of the country. The pitting of boilers in Chicago so far as this company's experience goes appears to be confined to that class of boilers used for cooking, heating or similar purposes in which the water of condensation is used over and over again. In all sections of the country, boilers operated under similar conditions are subject to pitting to a greater or less extent.

This company's inspectors, who work in Chicago and throughout the State of Illinois, report that there is no appreciable difference as to pitting, between the boilers operated in the city and boilers operated elsewhere in the state.

From another and well known company we received the following:

The average boilers in Chicago are probably in better condition than they are in some other locations, for instance, Pittsburgh, where pitting and corrosion are very marked. In Chicago we find but very little pitting and corrosion except in boilers used for heating purposes, where the pressure is low and the circulation is not very rapid, and where water is used from the returns, which naturally would cause considerable pitting.

We do not know what the percentage of pitting of boilers would be in Chicago, but we do know that the power boilers that we have inspected are probably freer from pitting than they are in most other localities, as we find that the water generally used for boiler-feed purposes is good.

From the above it can be seen that the statement of Mr. Herzog is wrong and that the feed water is more to blame than the furnace.

H. Misostow.

Chicago, Ill.

Referring to Mr. Herzog's letter in the issue of July 15, concerning the pitting of boilers, I am of the opinion that oxidation takes place both where the drop forms on the top plate and where it strikes the bottom plate.

If one crawls into the drum of a boiler free from scale and which has a leaky stop valve, it will be noticed that the vapor condenses on the sides and top of the drum. This condensation being chemically pure oxidizes the sheet both where the drop forms and falls.

Harry A. Cox.

Middletown, N. Y.

INQUIRIES OF GENERAL INTEREST

Circular Mil—What is the meaning of the term circular mil?

J. W. D.

A circular mil is the area of a circle 0.001 in. in diameter, or 0.0007854 sq.in., and is the standard unit of cross-sectional area of wires and cables for carrying electric current.

Condensing Surface—With brass condenser tubes of No. 18 gage thickness, cooling water at an initial temperature of 60 deg. F. and discharge temperature of 120 deg., how many pounds of steam per square foot per hour could be condensed?

J. W. D.

It would be considered good performance if 13 lb. per hr. were handled per square foot of condensing surface.

Highest Superheat—What is the highest temperature at which superheated steam is used?

S. E.

In this country a final temperature of about 500 deg. F. seems to be the practical commercial limit used in connection with steam turbines and poppet valve engines. In Germany temperatures of about 60 deg. F. are common and cases are on record where as high as 850 deg. F. has been used.

Resistance for Given Voltage Drop—What resistance is required to reduce a line voltage of 115 to 95?

J. A. P.

The amount of resistance required to reduce 115 volts to 95 volts will depend entirely upon the current. The drop across the resistance is $115 - 95 = 20$ volts, hence, from the formula

$$R = \frac{E}{C}$$

where

R = Resistance
E = Electromotive force or voltage
C = Current.

The resistance in ohms would be equal to 20 divided by the current in amperes.

Safe Flywheel Speed—At what speed (r.p.m.) can a 10-ft. flywheel be driven safely, having a rim with a 34-in. face, 3 in. thick? The wheel is in two sections and now runs at 90 r.p.m.

E. H.

In "Inquiries of General Interest," page 749 of May 21, 1912, issue of "Power," the method of determining the safe working speed of flywheels is given. With the strength of cast iron assumed as therein given, the safe speed would be 6085 ft. per min. for the flywheel rim. It is customary in figuring, however, to assume a mile a minute (5280 ft. per min.) as the limit of safe rim velocity in ordinary practice. A flywheel 10 ft. in diameter would have a circumference of 31.41 ft., and on the basis of a mile a minute, the safe speed would be $5280 \div 31.41 = 168$ r.p.m. The wheel being made in two parts, it must be assumed that the brackets or lugs and bolts for fastening the parts together have the same strength as the main body of the rim. If this is not so the safe speed would have to be taken as less than the above.

Thermal Efficiency—A steam engine develops 100 b.hp. consuming 500 lb. of steam in 10 min. If the temperature of the steam is 354 deg. F., its total heat 1190 B.t.u. per lb., and the temperature in the condenser 182 deg. F., what is the thermal efficiency, assuming the condensed steam to be returned to the boiler without loss?

S. S.

A horsepower being the development of work at the rate of 33,000 ft.-lb. per min., and 1 B.t.u. being equivalent to 778 ft.-lb., then

$$1 \text{ hp.} = \frac{33{,}000}{778} = 42.416 \text{ B.t.u. per min.}$$

and 100 hp. would be equivalent to 4241.6 B.t.u. per min. As each pound of steam supplied to the engine contains 1190 B.t.u. (reckoned above 32 deg. F.) and when returned from the condenser would be at 182 deg. F. (i.e. $182 - 32 = 150$ deg. above 32 deg. F.), then for each pound of steam used there would be supplied

$$1190 - 150 = 1040 \text{ B.t.u.}$$

and for the use of 500 lb. of steam per 10 min., which equals 50 lb. per min., the total heat supplied would be

$$1040 \times 50 = 52{,}000 \text{ B.t.u. per min.}$$

But as only 4241.6 B.t.u. was absorbed in performing useful work, the thermal efficiency of the engine would be

$$\frac{4241.6}{52{,}000} = 0.0815 \text{ or } 8.15 \text{ per cent.}$$

Steam from Pump—How can it be calculated how much steam will be required per day of 24 hr. by a duplex pump running at 75 r.p.m., having a piston 18 in. in diameter by 16-in. stroke, supplied with steam at 50 lb. pressure and exhausting into a vacuum of 20 in.

J. A. P.

The proper way to determine the steam would be to catch and weigh the condensate for a given time. It is not sufficient to estimate the weight from piston displacement as this does not allow for losses due to cylinder condensation and waste incident to clearance spaces. A rough method would be to estimate the horsepower developed and assume a rate of steam consumption. A duplex pump of the specifications given, with tight pistons and valves, should have a mean effective pressure on the pistons of about 65 lb. per sq.in., but for accuracy, the mean effective pressure should be determined by an indicator. Assuming 65 lb., the power developed in the steam cylinders would be

$$\frac{65 \times \frac{1}{12}^2 \times 254.47 \times 300}{33{,}000} = 200.5 \text{ hp.}$$

The water consumption of steam pumps of this kind varies with different designs, dryness of the steam supplied and mechanical construction. Under favorable conditions, using dry steam, the water rate would be about 35 lb. per hp. per hr., making the water consumption per 24 hr. run about

$$24 \times 35 \times 200.5 = 168{,}420 \text{ lb.}$$

Pipe Friction—Is there a simple formula for figuring the friction in a pipe line 500 ft. long, 12 in. in diameter with three 90-deg. ells and six 45-deg. ells?

J. A. P.

The formulas for flow of water in pipes are founded on mathematical deductions from experiments, and are not very simple. Elbow fittings vary in roughness and it is difficult to establish a law applicable to all cases. The friction of elbows is usually quoted in the number of feet of clean straight pipe of the same size which would cause the same loss of head as the fitting. The loss of head due to ordinary long turn ells (8 to 12 in. pipe) is taken as about equal to 4 ft. of pipe and for short turns about 10 ft. of pipe and 45-deg. ells would each be equivalent to about 7 ft. of the same size of pipe. The loss of head depends on the quantity or velocity of flow. With 3 short-turn ells (3×10 or 30 ft.) and six 45-deg. ells (6×7 or 42 ft.) the total loss in a line 500 ft. long would be equivalent to that in $500 + 30 + 42 = 572$ ft. of straight 12-in. pipe. A general formula for loss of head in feet is

$$h = f \times \frac{l}{d} \times \frac{v^2}{2g}$$

in which

h = Loss of head due to friction
f = Multiplier obtained by experiment which varies for different sizes of pipe
l = Length of pipe in feet
d = Diameter of pipe in feet
v = Mean velocity of flow in feet per second
g = 32.2, the acceleration of gravity.

Darcy's general formula, founded on extensive experiments, reduced to English units, is

$$h = \left(0.0199 + \frac{0.00167}{d}\right) \frac{l}{d} \times \frac{v^2}{2g}$$

In either of the formulas it is to be observed that the loss of head by friction is very nearly as the square of the velocity of flow and as the length of pipe. For rough calculations with small pipe it is quite common to figure the friction of an additional length of pipe as equivalent to each fitting.

ENGINEERS' STUDY COURSE

Evaporation—III

Equivalent Evaporation

By referring to the steam table published with last week's lesson it will be noticed that the total heat in a pound of steam gradually increases as the pressure increases. Thus, at atmospheric pressure the total heat of a pound of steam is 1150.4 B.t.u., while at 165 lb., abs., it is 1195 B.t.u. The heat required to generate steam at a pressure of 125 lb., abs., starting with feed water at 100 deg., is 1122.3 B.t.u. The proof is this: The total heat above 32 deg., as shown by the steam table is 1190.3 B.t.u. But 68 B.t.u. were already in the water because we started with the water at 100, instead of at 32 deg., and as 1 B.t.u. will raise the temperature of 1 lb. of water 1 deg., it is evident that (100 — 32) x 1 = 68 B.t.u. had already been supplied.

Then, the heat required to generate a pound of steam depends upon the pressure at which the steam is to be generated and the temperature of the feed water. It seldom happens that two boiler plants are exactly alike in both of these respects and, hence, when the performance of one plant is being compared with that of another, in order to be fair, it is necessary to have a common ground for comparison. One engineer might state, "I get an actual evaporation of 10.5 lb. of water per pound of coal," meaning that for every pound of coal fired into the furnace, 10.5 lb. of water were actually evaporated into steam under the conditions existing in his plant. He might think that he was making a better showing than his neighbor, who, although using exactly the same grade of coal, was getting an actual evaporation of 10 lb. per pound of coal. Yet, when the boiler pressure and feed-water temperature in both plants are taken into consideration, it might be shown that the man in the other plant was securing better efficiency even though the quantity of water actually evaporated per pound of fuel was somewhat less.

Assume that in the first-mentioned plant the steam pressure carried was 115 lb. per sq.in., abs., and the temperature of the feed water was 200 deg., while in the second plant the pressure was 190 lb., abs., and the feed-water temperature 100 deg.

In the first plant, the heat required to generate a pound of steam was

Total Heat in the Steam Above 32 Deg.		Heat in Feed Water Above 32 Deg.		
1188.8	—	168	=	1020.8 *B.t.u.*

And in the second plant the required heat was

Total Heat in the Steam Above 32 Deg.		Heat in Feed Water Above 32 Deg.		
1197.3	—	68	=	1129.3 *B.t.u.*

In the first plant 10.5 lb. of water were actually evaporated per pound of coal. Then, of the heat liberated by the combustion of 1 lb. of coal

$$1020.8 \times 10.5 = 10{,}718 \text{ } B.t.u.$$

were absorbed by the boiler and went toward useful work by generating steam.

In the other plant, 10 lb. of water were actually evaporated per pound of coal, yet

$$1129.3 \times 10 = 11{,}293 \text{ } B.t.u.$$

or 575 B.t.u. more were absorbed and went toward useful work than in the first case. Consequently, as the same quality of coal was used in each case, the efficiency of the latter plant was higher than the former.

This example emphasizes the importance of having a standard method of comparison so that the performance of all plants, no matter how widely the feed-water temperature and the steam pressure may vary, can be compared with complete fairness. The method used is to calculate the number of pounds of water that could be evaporated from a feed temperature of 212 deg. into steam at the same temperature by the heat used in evaporating 1 lb. of water from the feed temperature used in the plant discussed into steam at the pressure actually employed in that plant. The ratio of the evaporation at 212 deg. to the actual is called the "factor of evaporation." And when the number of pounds of water actually evaporated is multiplied by the factor of evaporation the product is the "equivalent evaporation" or the evaporation "from and at 212 deg."

The factor of evaporation may be found by the simple formula

$$F = \frac{(H - t) + 32}{970.4}$$

where

F = Factor of evaporation;

H = Total heat in the steam above 32 deg.;

t = temperature of the feed water.

Applying this formula to the first plant mentioned in the example just given, the factor of evaporation is found to be

$$F = \frac{(1188.8 - 200) + 32}{970.4} = 1.052$$

Multiplying together the pounds of water actually evaporated per pound of coal and the factor of evaporation, we have

$$10.5 \times 1.052 = 11.05 \text{ } lb.,$$

the equivalent evaporation per pound of coal. This quantity is called the equivalent evaporation because the heat put into 11.05 lb. of water at 212 deg. to make steam at 212 deg. (atmospheric, or 14.7 lb., abs., pressure) is exactly the same as the heat put into the 10.5 lb. at 200 deg. to make steam at 115 lb., abs., pressure. Hence, the two quantities are equivalent from the standpoint of heat.

Boiler Horsepower

The name horsepower was originally applied to the steam engine. James Watt, who did great work in the eighteenth century developing the steam engine, rated his engines as being able to do as much work as a certain number of work horses, hence, the unit, horsepower, which has been employed ever since. When it became

desirable to apply a unit to the output or capacity of a boiler, the same name was employed. Thus, a boiler which could supply steam enough to operate a 100-hp. engine was called a 100-hp. boiler. But such a standard without further qualification was very indefinite indeed. First, because various types and sizes of steam engines require widely different quantities of steam per horsepower-hour, and second, because a boiler of given dimensions may be made to generate steam at a greatly varying rate, depending on how hard the fire is forced.

Finally, an exact standard was selected and a boiler horsepower was established as the evaporation of 30 lb. of water per hour from a feed temperature of 100 deg. into steam at a pressure of 70 lb., gage, or the equivalent evaporation of 34.5 lb. of water per hour from and at 212 deg. This standard suffices to determine the output of a boiler when in operation, but it gives no means of determining the dimensions of a boiler for a given duty. In other words, a man who wished to purchase, say, a 200-hp. boiler, had no means by which he could calculate the area of the heating surface the boiler should possess and, hence, he was forced to depend upon the manufacturer's judgment. To avoid confusion and misunderstanding, it was, therefore, necessary to establish a standard for the area of heating surface necessary to develop one boiler-horsepower. At present, this standard is generally accepted as, 10 sq.ft. Thus, if a man purchases a boiler of 150-hp. rating, he expects to get a unit of such dimensions as to possess 1500 sq.ft. of heating surface. Heating surface is defined as that portion of shell, tubes and other parts which is in contact with the gases of combustion on one side and the contained water on the other.

Quality of Steam

Steam from practically all boilers, unless it passes through a superheater, contains moisture, that is, minute particles of water that has not been changed from its liquid form into the true vaporous state. By innumerable experiments it has been proven far beyond any doubt that when a pound of water at a certain temperature is evaporated into steam at a certain pressure a certain definite amount of heat is required. Now, then, if we condense a pound of what we assume to be "pure" steam (that is, saturated steam) by injecting it into a known weight of cool water and then carefully compute the heat it contained from the rise in temperature of the cooling water, we might find that the steam did not contain all the heat that, according to the steam table, it should. In such a case we would know that the steam contained "moisture" or was "wet."

The reason why a pound of wet steam does not contain all the heat it should is because the part that still exists as liquid water, no matter how fine or minute the particles may be, has not taken up any latent heat.

To illustrate with an actual numerical example, let us assume that we are investigating 100 lb. of wet steam that has been given off from a boiler at 125 lb., abs., pressure. According to the steam table, a pound of pure or dry saturated steam at 125 lb., abs., pressure should contain 1190.3 B.t.u. total heat above 32 deg., F., and, hence, 100 lb. should contain 119,030 B.t.u. If this 100 lb. were injected into 6000 lb. of water at 60 deg., the resultant weight of water would be 6100 lb. and the heat it should contain above 32 deg. would be the 119,030 B.t.u. before mentioned plus 6000 times the degrees difference between 32 and 60, or 168,000 B.t.u. One B.t.u. being the quantity of heat required to raise 1 lb. of water 1 deg., it is evident that

$$6000 \times (60 - 32) = 168{,}000 \ B.t.u.$$

would have to be put into the water in raising it from 32 to 60 deg. Thus, the total heat above 32 deg. contained in the 6100 lb. of water should be

$$119{,}030 + 168{,}000 = 287{,}030 \ B.t.u.$$

And, as the number of degrees in temperature above 32 deg. must be the total heat contained in the water divided by the weight of the water in pounds the new temperature after the steam has been injected should be

$$32 + (287{,}030 \div 6100) = 79 \ deg.$$

But, if the thermometer showed that the actual temperature was only 78.6 deg., and if there had been no radiation loss, it would be evident that there was a deficiency in the heat added to the water by the steam of

$$(79 - 78.6) \times 6100 = 2440 \ B.t.u.$$

Then, the entire 100 lb. of what we assumed was steam in actuality must have been only part steam and part liquid water.

Now, as the temperature of this liquid water carried in the steam is the same as that of the steam itself (if for no other reason than because the steam and particles of water arose together from the main body of water in the boiler), it is evident that the heat of the liquid is not deficient, the entire 100 lb. being at the boiling temperature. Consequently, the deficiency must all be due to the fact that some of the latent heat was not absorbed. This being the case, the number of pounds of water not converted into steam but simply floating in the steam in small particles (thus contributing to the weight of the mass just the same as though it all were steam) may be discovered by simply dividing the number of lacking B.t.u. by the latent heat of 1 lb. of steam at the given pressure, 125 lb., abs., thus,

$$2440 \div 874.7 = 2.8 \ lb.$$

Then, of the 100 lb. of what we assumed was steam only

$$100 - 2.8 = 97.2 \ lb.$$

or 97.2 per cent. really is steam. We say, consequently, that the "quality" of this steam is 97.2 per cent., or that the steam is "97.2 per cent. dry."

Practice Problems

A boiler is running under 120 lb., abs., pressure on feed water at 160 deg. What is the factor of evaporation?

If the actual total evaporation per hour is 8670 lb., what is the number of boiler horsepower being developed?

❖

Washington Coal Production in 1912—The coals of Washington have a wide range in character—from anthracite to lignite. The coking coals of Washington are the only ones of that grade on the Pacific coast. The coal-mining industry of Washington has suffered considerably during the last few years from the competition of fuel oil from California, the former principal consumers of Washington coal, the Puget Sound steamers and the railroads, having adopted petroleum for fuel. The production of coal in Washington reached its maximum in 1910, when the output amounted to 3,911,899 short tons, according to E. W. Parker, of the United States Geological Survey, who compiled the figures in cooperation with the Washington State Geological Survey. It decreased to 3,572,815 tons in 1911 and to 3,360,932 tons in 1912. The value fell off considerably less in proportion, from $8,174,170 to $8,042,871.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Wish folks would stop pestering the Panama engineers. A doubtless very wise old gentleman, quoted as being in charge of "enlarging the Amazon River's mouth," says the Canal is too shallow. Our veneration for old gentlemen on the shady side of 70 forbids our emitting a "spill" on an enlarged mouth, or we would bust right out in meeting.

❖

Then, too, if the Canal engineers have to spend much more time answering the criticisms of newspapers and those engineers who know so much better how to dig it than the men on the job, we will never get it finished.

❖

A good man and true heroically went to death in the hold of the "Imperator," after saving hundreds of lives. He was Second Officer Karl Gobrecht. And the irony of it all is that he was within a few feet of safety when the air tube of his smoke helmet and his guide rope tripped him in a companion-way filled with ammonia fumes and smoke.

❖

They're toting out the old Missouri River again, proposing to dam it. Well, go ahead and dam it. Dam it, and dam it now! Show old Missouri!

❖

Our mail at this writing has many postcards showing bright, level-headed engineers gazing into the distance—probably trying to see Springfield. Usually the cards have this legend. "Our worthy and esteemed brother, ——— ———, is a candidate for the high office of," etc. Too bad they can't all be elected.

❖

R. O. Richards, in the foreword "Engineer or Greaser?" of this issue, strikes deep into a big subject. Of course, you and I are corking good engineers, and the foreword does not include us. But, oh, the number of wild greasers we have known!

❖

I've allus noticed thet some people air purty much like the guv'ner of an old Corliss—ther faster they try to go, ther higher up in ther air they git.—S. Kirlin.

❖

McGraw's team the best-paid team we have? Only pikers! Why, Charley Naylor, chief engineer, the Marshall Field Co., just for a diversion, plays ball with the Chicago Retail Managers, whose salary checks would make $400,000 look like admission to the movies. We'd just like to see Chief Naylor pitted against Chief Meyers. Somebody would get massacreed!

❖

The Union Street Ry. Co., of New Bedford, has equipped its storeroom employees with roller skates; says the skates are timesavers. Also that the "operator" can climb a ladder without removing the skates. Great!

❖

He Wants an Explanation—Here is a letter from an anxious reader:

Gentleman—As I read on the cupon that the power com out every tuesday on the week, but as I have received Sunday sometimes monday and so on, and now is 2 weeks over Since I did not received anything at all why Such things happened I like to know your explanation

truly yours

MAX NICHTSAUS.

We've been explanationing all our long editorial life, but—Well, this stumps us. We'll wish this onto old Doc. Knowitall, the big cremo of the "Inquiries" department.

❖

Cop's Courage Stops Disaster—Headline. Oh, you funny daily press! Read this extract:

"Policeman Krause and Street Sergt. Wassing, at the risk of their lives, daringly went through the cellar filled with hissing steam, and turned off a safety valve. A terrific amount of steam pressure was by that time confined in the boiler, and there was imminent danger of an explosion that might have killed several people."

Louis D. Brandeis on Central-Station Rates

SYNOPSIS—Based upon court decisions in parallel cases, Mr. Brandeis' opinion is that where the cost of producing and delivering electric energy is the same regardless of the quantity supplied, there is no legal justification for discrimination. Where there is a difference between the cost of making and delivering electric energy to wholesale and retail consumers, then the difference in the selling price may not be substantially greater than the difference in cost.

❖

In a legal opinion submitted to the Uniform Electric-Rate Association, Louis D. Brandeis holds that the present system of rates charged by the majority of central stations is discriminatory and therefore illegal. In arriving at this conclusion, he cites the court decisions in several parallel cases of both private and public-utility corporations. His opinion is in part as follows:

Where no specific statute controls the actual or relative price to be charged by electric companies for their service, the right to charge depends, of course, upon the common law; and no good reason exists why the rules governing the relation of electric companies to the public, in respect to charges, should differ from that governing the conduct of the business of other public-service corporations.

It is well settled that ordinarily every public-service corporation must give to all members of the public equal opportunities in rates as well as in service. A public-service corporation may charge only a reasonable rate; but no rate can be fair or reasonable which is discriminatory; that is, which gives to one class of users a preference over another class. This rule does not, of course, prevent a reasonable classification in use. It merely requires that all persons served under similar conditions shall be treated alike. The first question to be decided is therefore this: Is a use in large or wholesale quantities similar to a use in small or retail quantities? The answer to this question must depend largely upon matters of fact. If the cost of producing and delivering electric energy is the same per unit, regardless of the quantity supplied, all things being taken into consideration, then the user in large or wholesale quantities must be deemed to be taking the electric energy under substantially similar conditions, and no legal justification exists for discriminating between them.

The rule forbidding discrimination on the ground of mere quantity of service has been recognized for over 30 years in railroad transportation, having been laid down by Judge Baxter in the famous decision of *John Hays & Co. vs. the Pennsylvania Railroad.* In that case, it appeared that the railroad company had fixed a rate between certain points at $1.60 per ton, with a rebate of from 30 to 70 cents per ton to all persons or companies shipping 5000 tons or more during the year—the amount of rebate being graduated by the quantity of freight furnished by each shipper. The railroad company contended that if the discrimination was made in good faith and for the purpose of stimulating the product and increasing its tonnage, it was both reasonable and just and within the discretion confided by the law to every

common carrier. The court, however, held the discrimination to be illegal, saying:

The discrimination complained of rested exclusively on the right of freight supplied by the respective shippers during the year. Ought a discrimination resting exclusively on such a basis be sustained? If so, then the business of the country is in some degree subject to the will of railroad officials, for if one man engaged in mining coal and dependent on the same railroad for transportation to the market, can obtain transportation thereof at from 25 to 50 cents per ton less than another competing with him in business, solely on the ground that he is able to furnish and does furnish the larger quantity for shipment, the small operator will sooner or later be forced to abandon the unequal contest and surrender to his more opulent rival. If the principle is sound in its application to rival parties engaged in mining coal, it is equally applicable to merchants, manufacturers, millers, dealers in lumber and grain, and to everybody else interested in any business requiring any considerable amount of transportation by rail. A discrimination in favor of parties furnishing the largest quantity of freight and solely on that ground, is a discrimination in favor of capital, and is contrary to a sound public policy, violative of that equality of right guaranteed to every citizen, and a wrong to the disfavored party for which the courts are competent to give redress.

The mere fact that in the case of the wholesale customer for electric energy, the public-service company would be exposed to the competition of a possible isolated plant; whereas, in the case of the retail customer, there is no possibility of his supplying himself, does not afford any legal justification for difference in charge. In other words, the possibility of competition is not to be taken into consideration in determining the reasonableness of the classification. This proposition was also clearly stated in a decision of Judge Baxter in the case of *Handy vs. the Cleveland & Marietta Railroad Co.* In that case, the receiver of the railroad charged Wright, a refiner of oil, 35 cents freight per barrel, while it charged the Standard Oil Co. only 10 cents per barrel for a like service, and in addition gave it a rebate of 25 cents on all oil shipped by Wright. The justification offered for this discrimination was that the Standard Oil Co. owned a pipe line by means of which it controlled a large amount of space which the railroad wished to secure; that the railroad had to yield to the oil company's demands, for the company would otherwise extend its pipe lines and carry all the oil through them.

The Court held that these facts constituted no excuse for the discrimination, saying:

Railroads are constructed for the common and equal benefit of all persons wishing to avail themselves of the facilities which they afford. All unjust discriminations are in violation of sound public policy and are forbidden by law, and except in the mode of using them, every citizen has the same right to demand the service of railroads on equal terms that they have to the use of a public highway or the government mails.

Assuming that there is a difference between the cost of making, delivering and selling electric energy between the wholesale and retail consumer, a public-service corporation can, in the absence of any statutes regulating or limiting the price at which it shall be sold, make a higher price to the retail customer, but the difference in the selling price may not be substantially greater than the difference in cost.

As to the right of a public-service corporation to make a substantial difference in its charges, based upon the broad purpose for which it is used, namely, a difference between light and power, there is more doubt. Some decisions of the state courts would seem to justify such discrimination, but the great weight of authority, as well as of reason, seems opposed to permitting any discrimination based upon the use to which the electric energy is put, and, therefore, upon the facts assumed in the question, such discrimination between charges for electric energy for power and charges for electric energy for light should be held illegal.

On the other hand, the difference between day use, when the demand upon the station is small, and evening use, when the demand upon the station is large, seems a proper basis of classification of service, and a court might, for this reason, upon the facts disclosed in a particular case, hold that the use for power, as calling mainly for day use, falls within a different class of service than use for light.

It seems clear, however, that mere difference in the value of the service or its character to the user, does not afford any justification for discrimination in rates.

Very closely in point are the decisions in regard to the supply of natural gas. In the case of *Bailey vs. the Fayette Gas Fuel Co.*, it was held that a natural gas company, organized to supply gas for lighting, heating and other purposes, has no power to make a difference in price according to the use to which the gas is put by the consumer; that is, making a lower price for gas used for power than where it is used for light.

In the case of the *Richmond Natural Gas Co. vs. Clawson*, the same decision was reached. There the company sought to fix the price of gas for fuel purposes at 12½c. per 1000 cu.ft., and to those consumers who used it for both fuel and illuminating purposes, at 20c. per 1000 cu.ft. The court held that this was unjust discrimination.

The Myriawatt

The following are extracts from a letter to the *Electrical World* from W. D. Weaver, its former editor, declaring against the advisability of adopting the myriawatt* as a unit of power:

The absolute lack of any scientific basis for the proposed "new power unit" can easily be shown. It is absurd to endeavor to perpetuate, without possibility of further revision, a boiler power rating based upon an engine heat consumption per horsepower-hour corresponding to the thermal units in 34.5 lb. of steam evaporated from and at 212 deg. F.—this at a time when a lengthy search would have to be made to find an engine of such inferior efficiency, in a day when steam prime movers are sold on a guarantee, on the above basis, of less than 10 lb. of water, and when a claim is made for a figure below 8 lb. The decimal relation upon which the myriawatt rests is entirely fortuitous in any scientific, or even schoolboy, sense—the relation would actually be 20 or 30 instead of 10 if the horsepower rating of boilers more nearly corresponded with present-day engine efficiencies. The fundamental and sole base of the proposed "unit," the quantity 33,479, or approximately ten times the value of the kilowatt-hour in pound-Fahrenheit thermal units (3415), is merely the product of 34.5 (pounds of water) by 970.4 (thermal units to evaporate 1 lb. of water from and at 212 deg. F.) Any rating connecting a boiler with an engine which is based upon a standard evaporation is a scientific absurdity, for the reasons, among others, that there is no physical relation between the boiler evaporation and the specific steam consumption of an engine, and that the rate of evaporation which fixes the supply of energy to the engine depends upon many independent boiler variables, such as heating surface, ratio of grate to heating surface, type of boiler, kind and quality of coal, kind of draft, method of firing, etc. Scientifically and practically the "new unit" would have little more status than a hydraulic power unit based, in connection with a "standard" head, upon the size of a water-power dam.

The myriawatt, does not in a single particular differ from the existing trade horsepower boiler rating except in name

*See the following issues for previous matter on the subject Aug. 27, 1912, p. 289; Jan. 21, 1913, p. 101; June 3, 1913, p. 800; June 24, 1913, p. 917.

and in an increase of about 2 per cent. in value. The grave practical fault of a boiler rating based upon a standard evaporation—a fault which has prevented the use of such a rating in Europe, has led to its entire neglect in this country by the marine engineering profession and by boiler designers, and to its little use by technically educated engineers in general—is that it does not even give a close clew to the size of a boiler for a specific service. For example, the boilers at the Detroit Delray generating station, which would be rated in the proposed nomenclature at 2365 myriawatts each, are said each to supply steam for the generation of 7500 kw. Again, a boiler of 100 myriawatts actual on the basis of natural draft and anthracite coal for fuel would, say, increase to 125 myriawatts actual with good soft coal, to 150 myriawaats actual with high chimney draft, and to 200, 300 or more myriawatts actual with forced draft.

Although a matter of relatively little moment, the name of the "new power unit" is also not free from objection, both as relates to the prefix "myria" and to the status of the "ten-thousand" metric multiple. While the word from which it is derived means, in Greek, ten thousand, in English it has the indefinite significance of "a great number." Even the French have halted at the "myria" metric nomenclature, which has never received practical adoption in France or elsewhere. The reason is perhaps that it was unconsciously felt to be illogical to use a unit that would compel one to think in terms of, say, four ten-thousands instead of forty thousand.

❧

Dedication of Keokuk Plant

The huge dam across the Mississippi River and the water-power plant at Keokuk, Iowa, described in our issue of Aug. 5, were formally dedicated on Aug. 26. The occasion was celebrated with a parade through the business streets, formal exercises at Rand Park, a regatta on Lake Cooper, the title given the artificial lake formed above the dam, and elaborate fireworks in the evening. Many prominent men made appropriate addresses, among them being Governor George W. Clarke, of Iowa, Lieutenant-Governor W. R. Painter of Missouri, Lieutenant-Governor W. L. Harding, of Iowa, former Representative William P. Hepburn and Judge William Logan.

❧

A New Society for Uniform Electric Rates

Prompted by the knowledge that present central station activities are breaking into the legitimate field for their products, a number of manufacturers of small power-plant equipment have formed an organization known as "The Uniform Electric Rate Association." The sole object is to agitate for a uniform charge for electric energy, sold by central stations, by appealing to state public-service commissions and by prosecuting illegal rate discrimination by such corporations throughout the United States.

The membership is open to any mechanical or electrical engineer in public practice or any person, partnership or corporation engaged in the manufacture of individual power-plant apparatus. All expenses connected with the organization and the prosecution of its purposes are met by voluntary contributions.

NEW PUBLICATIONS

MANUAL FOR ENGINEERS. Compiled by Charles E. Ferris, Professor of Mechanical Engineering, University of Tennessee and published by the University Press. Size, 3x6 in., 170 pages; flexible leather. Price 50c.

This is in no sense an engineering handbook, but rather a little volume of vest-pocket size containing various useful tables and data such as the engineer is often called upon to use in solving problems offhand. It also contains instructions to be followed in the case of electric shock, shop injuries, antidotes for poison, etc., all of which should make the book useful to the active construction or operating man.

THE MOTOR AND THE DYNAMO. By James L. Arnold, Professor of Electrical Engineering, New York University. The Chemical Publishing Co., Easton, Penn., 1913. Cloth; 6x9 in.; 178 pages, illustrated. Price, $1.50.

Although intended to meet the needs of both the college student and the practical electrician, the book is written rather from the viewpoint of an instructor and is more adapted to the classroom than to home study.

The subject is introduced by a chapter on mathematical principles which is followed by a very lucid explanation of the current actions in the dynamo, after which the author plunges into the rudiments of design involving theory and mathematical treatment. It does not go far enough into the problems of design, however, to be of service to the electrical designer. Interspersed with these are practical considerations on the care and operation of dynamos.

The second half of the book deals with alternating current machinery, the elementary considerations of which are presented clearly. An attempt has been made, however, to cover too much ground in too little space which has made it necessary to only very briefly touch upon certain important classes of electrical machinery.

FACTORY LIGHTING. By C. E. Clewell. Published by McGraw-Hill Book Co., New York, 1913. Size 6x9 in.; 161 pages. Price, $2.

It is now generally recognized that good lighting is a large factor in practically all lines of manufacture, being an aid to good workmanship, health of the employees and a reduction in manufacturing costs. The book aims to tell in a simple way how to obtain good lighting, but instead of prescribing set rules, actual installations are made the basis for analysis and explanation so that they may be useful in similar problems under varying conditions.

Chapters are devoted to General Items and Requirements of Illumination Design, Lighting Installation Work, Lighting Maintenance and Records, Office Lighting, Drafting Room Lighting, Factory Lighting, Power House Lighting, Iron and Steel Mill Lighting and Machine Tool Lighting.

In the chapter on Power House Lighting, the engine room, boiler room, coal bins and conveyors, and the transformer, oil switch and busbar compartments are considered separately. Where the ceiling is low or of medium height it is shown that a large number of medium sized tungsten lamps give more satisfactory results; whereas with a high ceiling a smaller number of lamps of high candlepower are permissible.

SOCIETY NOTES

The regular meeting on Aug. 23 of Minnesota Association No. 2 (Minneapolis) of the National Association of Stationary Engineers was one of the best attended and most enthusiastic meetings it has held this year.

State-President Mueller, chief engineer, Washburn-Crosby Co., who was a delegate of the American Society of Mechanical Engineers to Germany, was present and gave an interesting and instructive talk regarding his trip. Immediately after his address he was presented with a gold watch charm by the association in appreciation of his efforts during the past year as chairman of the educational committee.

Peter Ulstrom, chief engineer of the C. A. Smith Lumber Co., who left Minneapolis for Oregon some months ago to act in the same capacity for the Smith interests in that state was also present, having returned to again assume charge of the Minneapolis plant. He presented the association with a hand-carved gavel, which he had made in Oregon.

Following the meeting all present were invited by State-president Mueller to an informal lunch at Schieks Café, and about 75 accepted the invitation.

At the next meeting of the association, September 13, Mr. Mueller will discuss the German and Swiss industries that he visited while abroad.

PERSONALS

Lockwood, Greene & Co., architects and engineers for industrial plants, 60 Federal St., Boston, Mass., have established a Canadian office under the name, Lockwood, Greene & Co., of Canada, Ltd., with headquarters in the McGill Building, Montreal.

Fred R. Low, editor of "Power," returned Aug. 28, from an extended trip abroad. After attending the joint meeting of the American Society of Mechanical Engineers with the Verein Deutscher Ingenieure, in Germany, June 19 to July 8, he visited the principal industries connected with the power field in that country and also in Switzerland, France, Belgium, England and Scotland.